V. STATUS OF CALIFORNIA COHO SALMON POPULATIONS NORTH OF SAN FRANCISCO

Structure and Function of Viable Salmonid Populations

Structure of Pacific Salmon Populations

The McElhany et al.'s (2000) definition of population is used for the purposes of this review. This definition is much the same as Ricker's (1972, as cited in McElhany et al. 2000) definition of "stock": "An independent population is a group of fish of the same species that spawns in a particular lake or stream (or portion thereof) at a particular season and which, to a substantial degree, does not interbreed with fish from any other group spawning in a different place or in the same place at a different season." The term "coho salmon population" in this document typically refers to spawning adults. However, the term "population" also may be used at times to refer to juveniles, or adults in the ocean.

The Department defines and manages runs of anadromous salmonids based on genetic distinctiveness, run-timing differences, juvenile outmigration timing, and watershed (CDFG 1998). In many cases, California coho salmon populations roughly correspond to distinct spawning runs within watersheds. However, there is not enough information to assess connectivity between groups of spawners in different reaches of large streams. The relationship of tributary spawners to one another and to mainstem spawners is similarly unknown. Therefore, coho salmon spawning runs may actually be composed of more than one population.

Salmon have strong fidelity to breeding in the stream of their origin. This provides the potential for substantial reproductive isolation of local breeding populations, and may result in significant local adaptation. Isolated populations are subject to different levels of genetic drift and unique natural selection pressures that tend over time to result in differences between them. In addition, populations arising through colonization or artificial production, and populations that have experienced recent drastic reductions in size, are often genetically different from the population from which they were derived. Salmon also naturally exhibit a small and variable amount of exchange among populations that tends to connect them genetically, and make them more similar to one another. Even small amounts of gene flow between stocks (e.g. due to straying) can prevent their complete separation unless there is strong differential selection to maintain separation (Nei 1987). The amount of exchange may be influenced by factors like stream blockages (e.g. sandbars at the mouths of rivers or road crossings) and straying. Because of these factors, salmon populations are largely, but often not completely, isolated.

Levins (1969) proposed the idea of the metapopulation to describe a "population of populations". Metapopulations are comprised of subpopulations which are local breeding populations, with limited exchange among the subpopulations so that they are reasonably isolated and connected. Similarly, larger assemblages (e.g. all of the breeding populations in a watershed) can themselves form a metapopulation due to the connection between them afforded by natural straying. Fragmentation of this structure can affect the ability of populations to respond to natural environmental variation and catastrophic events.

Differential productivity among habitat patches can lead to a "source-sink" relationship in which some highly productive habitats support self-sustaining subpopulations (source

subpopulations) that continually supply individuals to other non-self-sustaining subpopulations (sink subpopulations) in less productive habitats (Pulliam 1988). Data for at least one coho salmon population in Washington (McElhaney et al. 2000) is consistent with this model. Because of the fact that sink subpopulations are not self-sustaining and rely on source subpopulations for their existence, Schlosser and Angermeier (1995), and Cooper and Mangel (1999) have stressed the importance of protecting natural source subpopulations. However, over longer periods, the relationship between source and sink subpopulations may change (i.e., sources may become sinks and vice versa). Thus, protecting only current source subpopulations may be inadequate to ensure long-term persistence. In some salmonid systems, hatchery and wild populations may represent sources and sinks, respectively (McElhaney et al. 2000).

Structure within a salmon species can be seen as hierarchical. Further, more than one logical hierarchical system can be envisioned. For example, NRC (1996) described the structure of genetic variation in salmon populations as beginning with substantially reproductively isolated local breeding populations that form metapopulations typically connected by some small amount of gene flow, followed by larger biological races, then subspecies/ecotypes, and culminating with the species as a whole. McElhaney et al. (2000) suggested a hierarchy containing individual, subpopulation, population, ESU, and species levels. An ESU can also function as a "metapopulation" (McElhaney et al. 2000). For purposes of this review, coho salmon populations are assumed to be organized in a hierarchical structure that includes connections among subpopulations as well as connections over a larger geographic scale.

Coho salmon have an almost fixed three-year life cycle throughout most of their range, including California (Sandercock 1991; Waples et al. 2001). Therefore, a complete generation of coho salmon in a stream consists of three consecutive, almost completely non-overlapping, brood-years[9]. Because of this, the number of locally-produced adults returning to a stream in a given spawning season is almost entirely dependent upon the number of juveniles produced there three years earlier. Loss of one of the three coho salmon brood-years in a stream (called brood-year extinction or cohort failure) therefore represents loss of a significant component of the total coho salmon resource in that stream. Brood-year extinction in a stream may be the result of the inability of adults to return to their place of origin, productivity failure, or high mortality. Recovery of an extinct coho salmon brood-year in a stream is made more difficult by its almost complete dependence on strays from other, usually nearby, sources (including hatcheries). Stray rates among natural populations are variable, unpredictable, and are probably low in healthy natural populations (McElhaney et al. 2000). This dependence on sources that may also be depressed and fragmented adds considerable uncertainty to the potential for natural recovery of missing coho salmon brood-years.

For purposes of this status review, each of the two California coho salmon ESUs is considered separately.

Population Viability Analysis

McElhany et al. (2000) defined a viable salmonid population for purposes of the ESA as "an independent population of any Pacific salmonid (genus *Oncorhynchus*) that has a negligible

[9] "Brood-year" or "cohort": Synonyms meaning a group of fish that hatched during a given spawning season. When the spawning season spans portions of more than one year, as it does for coho, the brood year is identified by the year in which spawning began. For example, offspring of coho that spawned in 1996-1997 are identified as "brood-year 1996" or "the 1996 cohort".

risk of extinction due to threats from demographic variation (random or directional), local environmental variation, and genetic diversity changes (random or directional) over a 100 year time frame." One hundred years was chosen to represent a long time-frame over which to evaluate risk of extinction. This long time scale is important because typical recovery actions can affect populations over many years. Many genetic processes (e.g. loss of diversity) can occur over long time-frames (decades or centuries), and at least some environmental cycles occur over decadal or longer time scales. By considering extinction risk far into the future, large-scale environmental oscillations and long-term trends can be accounted for. Short term viability (i.e. 10 or fewer years) is also considered. Evaluations of both long-term viability (i.e., 100 years) and short-term viability (i.e. 10 or fewer years) use the same parameters over different time scales.

The number of individuals that would ensure population viability to a negligible probability of extinction over 100 years is difficult to calculate (McElhaney et al. 2000). Evaluation of viability is based on assessments of abundance, population growth rate, population structure, and diversity. Reliable estimates of these parameters are not available for California coho salmon. Therefore, it is not possible to determine viability targets, in terms of numbers of fish, for coho salmon at this time.

For a description of habitat necessary to sustain viable coho populations, see Chapter IV *Summary of Essential Habitat.*

Sources of Information

Literature Review

Population abundance and trends have been estimated recently by Brown and Moyle (1991), Brown et al. (1994), and NMFS (2001a). Weitkamp et al. (1995) reviewed available population data in their status review of coho salmon. The Department reviewed the status of coho salmon north of San Francisco in a petition to the California Board of Forestry and Fire Protection (BOF) (CDFG 1994a). Status of coho salmon south of San Francisco was reviewed by the Department in response to a petition to list them under CESA (Anderson 1995). Distribution of coho salmon in California was also reviewed by Hassler et al. (1991). Nehlsen et al. (1991) reviewed Pacific salmon stocks at risk. Hatchery data and ocean catch data are also informative, and are reported here and in other sections of this document. In addition, the available coho salmon abundance and distribution data were subjected to a new analysis by the Department. The Department believes that these sources are the best available information on coho salmon abundance and distribution in California.

Presence-by-Brood-Year Investigation

Brown and Moyle (1991) reviewed the available information on coho salmon distribution and found records indicating historical occurrence of coho salmon in 582 California streams. Of these 582 streams, they found recent records of coho salmon presence or absence for 248 streams (42%). Their report summarizes published and unpublished information concerning the distribution and status of coho salmon in California.

To assess more recent trends in distribution and to augment Brown and Moyle's analysis, staff of the Department's Northern California - North Coast Region began an effort in 2001 to compile all historical presence information and data collected for 396 streams identified by Brown and Moyle (1991) north of Punta Gorda (includes streams from the Oregon border south to the Mattole River). Staff attempted to gather all published and unpublished data from as many streams as possible, including original field notes, planting records, and fish surveys found in north coast offices of the Department, United States Forest Service (USFS), USFWS, Barnum Timber Company, Pacific Lumber Company (PALCO), Forest Science Project, Simpson Timber Company, Yurok Tribal Fisheries Department, Humboldt State University Fisheries Cooperative Research Unit, Redwood National Park, and Sea Grant. In addition, data from scientific collectors and recently published status reviews such as Ellis (1997), Brownell et al. (1999), and NMFS (2001a) was reviewed. A standard protocol for document review was followed and all documents were reviewed at least twice. If a document indicated that more than one life stage of coho salmon was present, then the appropriate brood years were judge to be present for that stream.

Staff made no attempt to assess effort or effectiveness of sampling described in the documents, therefore the likelihood of finding coho salmon could not be determined. In addition, the number of coho salmon observed was not considered, i.e., presence could be determined based on an observation of only one fish. Some streams with no documentation were considered to have coho salmon present if fish were documented in an upstream tributary. In other words a stream could be classified as a coho salmon stream even if it only served as a migration corridor.

2001 Presence Surveys

As a result of the above investigation, streams without a consecutive brood year lineage were surveyed in summer and fall of 2001 to determine if coho salmon presence could be detected. Department survey efforts were augmented by coordinating research efforts with other agencies and scientific collectors. The Department contracted with the Forest Science Project and Humboldt State University to survey streams from Redwood Creek through Humboldt Bay. In addition, historical coho salmon streams south of the Mattole River were surveyed by the Department's Central Coast Region staff, Campbell Timber Management, Mendocino Redwood Company, Marin Municipal Water District, Center for Ecosystem Management and Restoration, Tomales Bay Association, and the National Park Service. A modified version of the NMFS's ten-pool protocol (Adams et al. 1996) was used (Appendix C-I). The primary sampling technique used was direct observation by snorkeling. Other sampling methods used were backpack electrofishing, seining, and baited minnow trapping. For the Central Coast Region, streams for which surveys indicated presence for three consecutive years between 1994 and 2000 were assumed to have an extant population of coho salmon and were not surveyed.

Historical and Current Distribution by Watershed

This section describes the historical and current distribution of coho salmon in California north of San Francisco. Much of the historical information was derived primarily from literature and file searches performed by Brown and Moyle (1991), Hassler et al. (1991), CDFG (1994a), Brownell et al.(1999), and Adams et al. (1999). Information on current range and distribution was taken primarily from Ellis (1997), Brownell et al. (1999), and Department field surveys and

document reviews conducted in 2001 (noted in the text as "CDFG unpubl. data"). Together, these sources comprise the only comprehensive information on coho salmon range and distribution within California north of San Francisco. The waters discussed below are streams and rivers for which coho salmon information currently exists and are arranged from north to south. Counties listed after the stream name represent those portions of the basin in which coho salmon were found historically.

"Historical information," for purposes of this report, is defined as information developed prior to 1995, while information developed in 1995 or later is considered current information. This corresponds to two brood year life cycles of coho salmon.

Winchuck River (Del Norte County)

Historical Distribution: The South Fork Winchuck River historically supported a small population of spawning coho salmon. Adult coho salmon were first reported in 1940, then again in 1979, 1992 and 1993 (Brownell et al. 1999; CDFG 1994a).

Current Distribution: Juvenile coho salmon were observed during surveys of the South Fork Winchuck River in 1996. Coho salmon juveniles of the 1997 and 2000 cohorts have also been reported in the South Fork Winchuck River (Ellis 1997). It appears coho salmon presence and distribution has changed little in the South Fork Winchuck River.

Illinois River (Del Norte County)

Historical Distribution: Within the California portions of the Illinois River system, Broken Kettle and Elk creeks, tributaries to the West Fork Illinois River, are known to have historically contained coho salmon. Dunn Creek, tributary to the East Fork Illinois River also historically contained coho salmon (Hassler et. al 1991).

Current Distribution: Coho salmon were recently confirmed in Broken Kettle Creek, the South Fork Broken Kettle Creek and Elk Creek. Coho salmon were also recently sighted in the East Fork Illinois and its tributaries, Dunn Creek and North Fork Dunn Creek (CDFG unpubl. data). Coho salmon distribution appears to have changed little within the California portion of this system.

Miscellaneous Del Norte County Coastal Streams

Historical Distribution: Coho salmon have been reported in Jordan and Yonkers creeks, tributaries to Lake Earl north of Crescent City (Hassler et al. 1991). Access to these two tributaries is at least partly dependant on when the sand bar that separates Lake Earl from the Pacific Ocean is breached. Coho salmon have also been reported in Elk and Wilson creeks, which connect directly to the Pacific Ocean (Hassler et al. 1991).

Current Distribution: Coho salmon have been confirmed in Elk and Wilson creeks since 1995. Coho salmon were not confirmed during recent surveys of Jordan and Yonkers creeks (CDFG unpubl. data).

Smith River (Del Norte County)

Historical Distribution: The Smith River basin is California's fourth largest coastal river system. Coho salmon are found throughout, although their numbers are typically small. The more notable Smith River tributary systems in which coho salmon were reported historically are: Rowdy Creek, including its tributaries Dominie, South Fork Rowdy, Savoy and Copper creeks; Morrison, Jaqua (a.k.a. Little Mill), and Mill creeks, including both the West and East branches; Kelly and Bummer Lake creeks; and Middle and South Forks Smith River (Brownell et al. 1999). Coho salmon have also been reported historically in smaller tributaries such as Sultan, Peacock, and Clarks creeks, (Brownell et al. 1999).

Within the South Fork sub-basin, coho salmon have been reported in Craigs, Coon, Rock, Hurdygurdy, Jones (and its tributary Muzzleloader Creek), Buck, Quartz, and Eightmile creeks, and the Prescott Fork Smith River. In the Middle Fork Smith River, coho salmon have been historically documented in Myrtle, Hardscrabble, Eighteenmile, Patrick, Monkey, Packsaddle, Griffin, and Knopti creeks, and the Siskiyou Fork Smith River. Twelvemile, Shelly, Elevenmile, Tenmile, and West Fork Patrick creeks (all tributaries to Patrick Creek) also supported coho salmon. Coho salmon historically utilized the North Fork Smith River, including its tributaries Stony, Peridotite, Still, and Diamond creeks (Brownell et al. 1999).

Current Distribution: In 1996, spawning coho salmon were reported in Mill Creek (Brownell et al. 1999). Juveniles have been observed in the West Branch Mill Creek as well as in the East Fork Mill Creek and its tributaries Bummer Lake, Kelly, and Low Divide creeks in recent years. Coho salmon have been confirmed in Rowdy Creek and its tributaries the South Fork Rowdy, Savoy, Dominie, and Copper creeks. Within the South Fork of the Smith River, coho salmon have only been confirmed in Eightmile Creek and in the mainstem South Fork. Recent surveys of Patrick Creek and Knopti Creek, tributaries to the Middle Fork Smith River, have resulted in confirmed coho salmon observations. Other Smith River tributaries where coho salmon have been documented since 1995 include Little Mill and Clarks creeks (CDFG unpubl. data).

Rowdy Creek Fish Hatchery, a small, privately operated hatchery on Rowdy Creek, has propagated coho salmon on an irregular basis since 1987. Adult coho salmon spawners returned to the hatchery in 1996, 1997 and 1998 (Brownell et al. 1999). They were also observed in 2001. Hatchery reared and released coho salmon have likely influenced adult returns to Rowdy Creek over the years.

Coho salmon presence was unconfirmed in most of the tributaries recently surveyed in the South and Middle forks Smith River in 2001 (CDFG unpubl. data). These two sub-basins constitute the majority of the Smith River tributaries that historically contained coho salmon. Coho salmon were observed in 2001 only in Mill and Rowdy creeks and their tributaries, Clarks and Little Mill creeks.

Klamath River (Del Norte, Siskiyou, Humboldt and Trinity Counties)

Historical Distribution: The Klamath River basin is California's second largest river system, draining a watershed of approximately 15,600 square miles.. The watershed is commonly divided into the Lower Klamath River, the Upper Klamath River, and the Trinity

River basins. Anadromous fish have been blocked from the Oregon reaches of the upper Klamath basin since 1918 when Copco No.1 Dam was constructed. Currently, anadromous fish have access to about 190 miles of the Klamath River (from Iron Gate Dam, near the Oregon border in Siskiyou County, to the Pacific Ocean at Requa in Del Norte County).

The Trinity River is the largest tributary to the Klamath River and drains approximately 1,369 square miles of watershed. The headwater streams originate in the pristine wilderness areas of the Trinity Alps and Trinity Mountains located in eastern Trinity County. The river flows 172 miles south and west through Trinity County, then north through Humboldt County and the Hoopa Valley and Yurok Indian reservations until it joins the Klamath River at Weitchpec, about 40 river miles (RM) from the Pacific Ocean. Anadromous fish passage is blocked by Lewiston Dam approximately 110 RM upstream from the mouth of the Trinity River.

Information on adult coho salmon returns to the Klamath basin is spotty prior to the construction of Iron Gate and Trinity River hatcheries. Counts of adult returns to the basin's hatcheries have been recorded since the facilities began operating in the 1960s. Counts of coho salmon observed at the Klamathon Racks, a mainstem weir located below Iron Gate Dam, were recorded during the 1920s and 30s. Although adult counts were not made, coho salmon eggs were collected at the Klamathon Station during its first year of operation in 1910. Adult coho salmon returns to the Shasta River, a major tributary to the Klamath River, have been documented since 1934. Similar information is lacking for the Scott and Salmon rivers, two other major Klamath River tributaries, as few attempts have been made to document their returns in the past **(see Appendix D, a report on the historical occurrence of coho salmon in the upper Klamath, Shasta, and Scott rivers)**. Snyder (1931) reported that significant coho salmon runs once occurred in the Klamath River, especially in the lower tributaries (below the Trinity River confluence). He found that 11,162 adult coho salmon were landed in one month by commercial gill-netting at the mouth of the river in 1919.

In the Trinity River, coho salmon have historically been observed in Scotish, Mill, Hostler, Supply, Campbell, Tish Tang a Tang, Horse Linto, Willow, Manzanita, Canyon, Browns, Conner, Dutch, Reading, Weaver (including its tributaries East and West Weaver), Rush, and Deadwood creeks, the South and North Fork Trinity rivers, and New River. Within the South Fork Trinity River, coho salmon have been documented in Madden, Eltapom, Pelletreau, Hayfork, Butter and Rattlesnake creeks (Brownell et al. 1999). They have also been documented in Big Creek, East Fork New River, tributaries to New River and in East Fork of the North Fork Trinity River (Hassler et al. 1991).

Other major Klamath Basin tributary systems that historically supported naturally spawning coho salmon include the Salmon, Shasta, and Scott rivers. In the Salmon River, coho salmon have been seen in Wooley Creek, Nordheimer Creek, and North Fork and South Fork Salmon River. In the Scott River, coho salmon have been documented in Tompkins, Kelsey, Canyon, Shackleford, Kidder, Etna, French, and Sugar creeks as well as the East and South Forks. Coho salmon have been documented in Big Springs Creek, a spring-fed tributary to the Shasta River (Brownell et al. 1999).

Many smaller Klamath River tributaries between the mouth and the Trinity River confluence that historically supported coho include: Hunter, Richardson, Hoppaw, Saugep, Waukell, Turwer, McGarvey, Omagar, Tarup, Blue, Ah Pah, Bear, Tectah, Pecwan, Mettah,

Roach, Miners, Tulley, and Pine creeks (Brownell et. al. 1999). Klamath River tributaries between the Trinity River confluence and Iron Gate Dam that also historically supported coho salmon are: Aikens, Bluff, Slate, Red Cap, Boise, Camp, Irving, Dillon, Swillup, Ukonom, Independence Clear, Oak Flat, Elk, Little Grider, Indian, China, Thompson, Fort Goff, Portugese, Seiad, Grider, Walker, Horse, Bark House, Beaver, Humbug, Lumgrey, Empire, Cottonwood, Willow, and Bogus creeks (Brownell et al. 1999). Coho salmon were historically documented in Fall Creek, which is now upstream of Iron Gate Dam (Coots 1957).

The Klamath River basin has two hatcheries that produce coho salmon. Iron Gate Hatchery, located at the base of Iron Gate Dam, was completed in 1966. Trinity River Hatchery is located at the base of Lewiston Dam and began operating in 1963. Both of these facilities are mitigation hatcheries designed to offset losses in salmon habitat above the dams.

Current Distribution: In the Klamath River downstream of the Trinity River confluence, coho salmon have occupied Hunter Creek every year since 1995. Coho salmon have also been confirmed in tributaries to Hunter Creek such as the East Fork Hunter and Mynot creeks. Other recent surveys have resulted in coho salmon observations in Hoppaw, Waukell, Saugep, Turwar, McGarvey, Tarup, and Omagar creeks. Since 1995, coho salmon have been seen in Blue Creek and its tributaries such as Pularvasar, One-mile, West Fork Blue and Nickowitz creeks and in the Crescent City Fork. In other tributaries of the Klamath River below Weitchpec, coho salmon juveniles have been confirmed in the Ah Pah, Bear, Tectah, Little Surpur, Johnson, Pecwan, Mettah, Roach, and Pine creeks (CDFG unpubl. data).

In the Klamath River above the Trinity River confluence, Brownell et al. (1999) reported finding coho salmon in Camp, Swillup, and Elk creeks and its tributary East Fork Elk Creek. They also reported finding coho salmon in China, Fort Goff, Portuguese, Seiad, Horse, Salt, Little Humbug, Beaver, and Humbug creeks. Other Klamath River tributaries in which coho salmon have recently been reported include Dillon, Swillup, One-Mile (tributary to Ukonom Creek), Independence, Clear, Indian (and its South Fork tributary), Grider, Cottonwood, Little Bogus, and Bogus creeks. Juvenile coho salmon were rescued from Dry Creek, an intermittent stream near Iron Gate Hatchery, in 1995 and 1996. In 1998, they were also observed in Blue Gulch, a seasonal intermittent stream a few miles downstream of Dry Creek (Dennis Maria pers. comm.). Iron Gate Hatchery has reported coho salmon returns every year since it began tracking returns in 1963.

During surveys that began in 1996, coho salmon were not observed in eleven minor Klamath River tributaries that are historical coho salmon streams. These were: Salt and High Prairie creeks (tributaries to Hunter Creek), Bluff, Slate, Red Cap, Boise, Irving, Thompson, Middle (tributary to Horse Creek), Barkhouse, and Lumgrey creeks (Ellis 1997; CDFG unpubl. data).

In the Trinity River, coho salmon have recently been seen in the mainstem and its tributaries, such as Horse Linto Creek, Willow Creek, the South Fork Trinity River and its tributaries Madden and Eltapom creeks, Sharber Creek, New River, Weaver Creek (including its East and West Forks), Grass Valley Creek, Rush Creek and Deadwood Creek. Kier Associates (1999) reported observing coho salmon juveniles in the East Fork of the North Fork Trinity River and in Big French and Canyon creeks. Adult coho salmon have returned annually to Trinity River Hatchery since the facility began operations in 1963.

Coho salmon were not observed in recent surveys of six streams that historically supported coho salmon within the Trinity River basin. These are: Pelletreau, Hayfork, Butter and Rattlesnake creeks (tributaries to the South Fork Trinity River), Manzanita Creek, and the East Fork of the North Fork Trinity River (CDFG unpubl. data).

Within the Salmon River drainage, coho salmon were recently observed in the mainstem and in the South Fork Salmon River (CDFG unpubl. data). Coho salmon were observed in Knownothing Creek in 1998 (Brownell et al. 1999). Coho salmon were not observed in recent surveys of eight historical coho salmon streams within the Salmon River basin: Wooley Creek, Nordheimer Creek, North Fork Salmon River and its tributary North Russian Creek, Methodist Creek, and the East Fork of the South Fork and its tributary Taylor Creek (CDFG unpubl. data).

Coho salmon have been observed in the mainstem Scott River as well as several of its tributaries. These tributaries include Canyon, Shackleford, Mill, Kidder, French, Miners, and Sugar creeks and South Fork Scott River and its tributary Boulder Creek (CDFG unpubl. data). In Mill Creek near the town of Scott Bar, one suspected coho salmon redd was observed in December 2001 and 5 juveniles were seen in October 2001. In 1996, 61 juvenile coho salmon were captured from Kelsey Creek during fish rescue operations. Ninety-six juveniles were rescued from the upper Scott Valley near the mouth of Sugar Creek that same year. Adult spawners were observed in 2001 in the South Fork Scott River (64 adults), Sugar Creek (40 adults), French Creek (25 adults), Miners Creek (5 adults), Shackleford Creek and its tributary Mill Creek (2 adults), and Patterson Creek (1 confirmed, several others suspected) (Dennis Maria pers. comm.). In surveys conducted since 1996, coho salmon were not observed in five historical coho salmon streams: Tompkins, Kelsey, Patterson, Big Mill (tributary to the East Fork Scott River) and Etna creeks.

Adult coho salmon returned to the Shasta River in 1996, 1997, 1999 and 2001, and annually to Iron Gate Hatchery since 1996. Adult coho salmon have also been reported in the Salmon (1996, 1997, and 1998) and Scott rivers (1996) and in Bogus Creek (1996, 1997, 1998, 1999, 2000, 2001) (Mark Pisano pers. comm.). Juvenile coho salmon were observed in the Shasta River during the springs of 2000 and 2001 (Bill Chesney pers. comm.).

The lack of observed coho salmon during recent surveys within the Klamath Basin does not necessarily imply they have been fully extirpated from those areas. It does, however, provide insight for potential problem areas.

Redwood Creek (Humboldt County)

Historical Distribution: Redwood Creek flows for 65 miles from the headwaters to the Pacific Ocean, draining an area of 282 square miles. Coho salmon were first reported in Redwood Creek in 1895 (U.S. Commission on Fish and Fisheries 1895). Prairie Creek and its main tributaries, Little Lost Man and Godwood creeks, produced relatively large numbers of coho salmon historically. Other tributaries such as Tom McDonald, Bridge, Coyote, Panther, and Lacks creeks have also historically supported coho salmon. Prairie Creek Hatchery, a small, State owned hatchery located on Lost Man Creek near the town of Orick, began producing coho salmon in 1928. Coho salmon fry were primarily released in waters of Humboldt and Del Norte counties (Leitritz 1970). Operation of Prairie Creek Hatchery was turned over to Humboldt County in 1957 and was closed in 1992 due to water quality concerns and funding issues.

Current Distribution: Coho salmon have been recently documented in Redwood Creek and its tributaries Elam, Tom McDonald, Bridge, Cole, Hayes, and Davidson creeks. Coho salmon are also found in Prairie Creek and in its tributaries Little Lost Man, Lost Man, May, Godwood, Boyes, Browns, and Streelow creeks. Coho salmon were not observed in Coyote, Panther, and Lacks creeks during recent surveys (CDFG unpubl. data).

Miscellaneous Humboldt County Coastal Streams

Historical Distribution: Coho salmon have been found in small coastal waters such as Big Lagoon and its tributary Maple Creek, and in Strawberry Creek. They have also been documented in Stone Lagoon and its tributaries McDonald and Fresh creeks (Brownell et al. 1999). In the southern portion of Humboldt County, Guthrie, and McNutt creeks are also known to have supported coho salmon (Brown and Moyle 1991; Hassler et al. 1991).

Current Distribution: Coho salmon have recently been documented in Strawberry Creek and in tributaries to Big Lagoon such as Pitcher, and Maple creeks. Coho salmon were not observed during recent surveys of McDonald and Fresh creeks, nor were they seen in Big Lagoon. No coho salmon were observed in a recent survey of McNutt Creek (CDFG unpubl. data).

Little River (Humboldt County)

Historical Distribution: Coho salmon were documented historically in the Little River mainstem, the South Fork Little River, and Upper and Lower South Forks Little River (Hassler et al. 1991; Brownell et al. 1999).

Current Distribution: During recent surveys, coho salmon have been observed in the Little River and its tributaries Railroad Creek, Carson Creek, Lower South Fork Little River and Upper South Fork Little River (CDFG unpubl. data).

Mad River (Humboldt and Trinity Counties)

Historical Distribution: The Mad River flows 100 miles through Trinity and Humboldt counties to the Pacific Ocean, draining approximately 497 square miles. Adult coho salmon were counted at Sweasey Dam between 1938 and 1963 (CDFG 1994a). Lindsay Creek and its tributary Squaw Creek have been known to produce relatively large numbers of coho salmon (CDFG 1994a; Brown and Moyle 1991). Coho salmon have also been reported in other tributaries such as Grassy, Noisy, Canon, Warren, Hall, Powers, Leggit, Palmer, Maple, Black, Boulder, Quarry and Dry creeks as well as the North Fork Mad River (Brown and Moyle 1991). Ruth Dam was built in 1961 about 80 miles upstream of the mouth of the Mad River in Trinity County to provide water for industrial use (e.g., pulp mills), domestic use, and hydroelectric power. The dam is a barrier to the migration of adult salmonids.

Current Distribution: Coho salmon have been recently observed in the Mad River and its main tributaries Warren, Lindsay, Hall, Canon, Maple, and Boulder creeks and the North Fork Mad River. Within the Lindsay Creek sub-basin, coho salmon have also been observed recently in the South and North Fork Anker creeks and Squaw and Mather creeks. However, they were not observed in Grassy Creek. Coho salmon have also been recently documented in Noisy

Creek, a tributary to Hall Creek, and in Canyon and Sullivan creeks, tributaries to the North Fork Mad River. Streams in which recent surveys failed to detect coho salmon presence are Mill (tributary to Hall Creek), Powers, Leggit, Kelly, Palmer, Dry, Quarry, and Black creeks (CDFG unpubl. data).

Coho salmon adults have recently been observed returning to Mad River Fish Hatchery (Patrick Overton, pers. comm.).

Humboldt Bay Tributaries (Humboldt County)

Historical Distribution: Historically, tributaries to Humboldt Bay, such as the Elk River and Jacoby Creek, have supported substantial populations of coho salmon. Freshwater Creek, as well as other tributaries to Eureka Slough, have also historically supported substantial populations of coho salmon (CDFG 1994a). Coho salmon have also been reported in Janes (trib of McDaniel Slough), Jolly Giant, Rocky Gulch, and Salmon creeks, and Fay Slough (Cochran Creek) (Brown and Moyle 1991; Hassler et al. 1991; Brownell et al. 1999).

Current Distribution: Coho salmon were recently observed in Jolly Giant Creek, Jacoby Creek and its tributary Morrison Gulch, Ryan Creek (tributary to Eureka Slough), Freshwater Creek and the Elk River. Within the Freshwater Creek system, coho salmon were observed in McCready Gulch, Little Freshwater Creek, Cloney Gulch, Falls Gulch, Graham Gulch, and the South Fork Freshwater Creek. In the Elk River system, coho salmon were observed in Martin Slough, North Fork Elk River, South Branch North Fork Elk River, South Fork Elk River, and Little South Fork Elk River (CDFG unpubl. data). Coho salmon were not observed during recent surveys of Janes, Rocky Gulch, Cochran, salmon, and College of the Redwoods creeks (CDFG unpubl. data).

Eel River (Humboldt, Mendocino, Trinity, and Lake Counties)

Historical Distribution: The Eel River is the third largest river system in California, encompassing approximately 3,681 square miles. Major sub-basins of the Eel River system include the mainstem Eel River (1,477 sq. mi.), North Fork (283 sq.mi), Middle Fork (753 sq. mi.), South Fork (690 sq. mi.), Van Duzen River (428 sq. mi.), and the estuary and delta (50 sq. mi.)

Mainstem Eel River flows have been regulated and managed for hydroelectric power and exported for agriculture since 1922. There are two dams associated with the Potter Valley Hydroelectric Project located on the upper mainstem Eel River: Scott Dam impounds Lake Pillsbury, a 94,000 acre-foot storage reservoir and, twelve miles downstream, Cape Horn Dam forms the 700 acre-foot Van Arsdale diversion reservoir.

In the mainstem Eel River, coho salmon historically occurred as far upstream as Indian and Tomki creeks (Brown and Moyle 1991). The Van Arsdale Fish Station, an egg taking station operated by the Department, is located at Cape Horn Dam. Coho salmon have been reported twice at this facility: 47 fish in 1946/47 and one fish in 1984/85. Other smaller tributaries to the mainstem where coho salmon have been reported historically include: Palmer, Rohner, Strongs, Price, Howe, Nanning, Monument, Killer, Twin, Stitz, Greenlow, Dinner, Jordan, Shively, Bear, Chadd, Larabee, Allen, Newman, Thompson, Jewett, Kekawaka, and Outlet creeks, the North

Fork and Middle Fork Eel Rivers, and the Salt River (Brown and Moyle 1991; Hassler et al. 1991; Brownell et al. 1999).

In the Van Duzen River, coho salmon have been historically documented in many tributaries of Yager Creek, and Wolverton (tributary to Barber Creek), Cuddeback, Fiedler, Cummings, Hely, Root, Grizzly, and Hoagland creeks (Brown and Moyle 1991; Hassler et al. 1991; Brownell et al. 1999).

Counts of coho salmon at Benbow Dam on the South Fork Eel River were made between 1938 and 1975. The largest number of fish reported was over 25,000 in 1947. Only 500 who were counted in 1973 (CDFG 1994a). There are a total of approximately 52 tributaries to the South Fork Eel River that have historically supported coho salmon (Brown and Moyle 1991; Hassler et al. 1991; Brownell et al. 1999). Of these, Bull, Redwood, Sproul, Indian, Bear Pen, Wildcat, Hollow Tree, Rattlesnake and Ten Mile creeks and the East Branch of the South Fork have tributaries that also supported coho salmon historically (Brown and Moyle 1991; Hassler et al. 1991).

Current Distribution: Recent field surveys have confirmed the presence of coho salmon in the Eel River and in tributaries such as the Van Duzen River (and its tributary Shaw Creek), Howe Creek, the South Fork Eel River, and in tributaries to Outlet Creek. Within the Van Duzen River sub-basin, another 14 tributaries were recently surveyed in which no coho salmon were observed: Wolverton Gulch (tributary to Barber Creek), Yager Creek and its tributaries Cooper Mill and Lawrence creeks, Cuddeback Creek, Fiedler Creek, Cummings Creek, Hely Creek, Root Creek, Wilson Creek, Grizzly Creek and its tributary Stevens Creek, Hoagland Creek, and Little Larabee Creek (CDFG unpubl. data).

Recently in the South Fork Eel River sub-basin, coho salmon were seen in Bull (and its tributary Squaw Creek), Canoe, Salmon, Sproul (and its tributaries Little Sproul and West Fork Sproul creeks), Redwood (and its tributaries Seely, China, and Dinner creeks), and Leggett creeks. Coho salmon were not observed in Warden Creek (tributary to Sproul Creek) or in Miller Creek (tributary to Redwood Creek). Other coho salmon streams in the South Fork Eel River system in which coho salmon have been recently observed include Indian, Piercy, Standley, McCoy, Bear Pen, Wildcat, Jack of Hearts, Dutch Charlie, Kenny, and Taylor creeks (CDFG unpubl. data). Coho salmon were not observed during recent surveys of Albee, Mill, Bridge, Elk, Fish, Anderson, Dean, Durphy, Milk Ranch, Low Gap, Red Mountain, Cedar, Rattlesnake (and its tributary Cummings Creek), Fox, Elder, Little Charlie, Rock, Haun and Bear creeks and the East Branch of the South Fork Eel River (CDFG unpubl. data).

Coho salmon have also been recently observed in the Hollow Tree Creek system, another tributary to the South Fork Eel River. Hollow Tree Creek tributaries such as Redwood (and its South Fork tributary), Bond, Michaels, Butler, and Huckleberry creeks were also found to contain coho salmon during recent surveys. Two small tributaries to Michaels Creek (Doctors Creek and an unnamed tributary) also contained coho salmon, as did Bear Wallow Creek and Little Bear Wallow Creek (tributaries to Huckleberry Creek). Coho salmon were not observed in Mule, Walters, and Waldron creeks (tributaries to Hollow Tree Creek). Likewise, coho salmon were not observed during recent surveys of Grub, Streeter, Big Rock, Mill and Cahto creeks, which are tributaries to Ten Mile Creek. Coho salmon were observed recently in Ten Mile Creek, however (CDFG unpubl. data).

Coho salmon have not been observed recently in the Middle Fork Eel River, nor in its tributaries Rattlesnake, Rock, Mill, and Grist creeks. In the Outlet Creek sub-basin, coho salmon were recently confirmed in Mill, Willits, Broaddus and Baechtel creeks (CDFG unpubl. data). Ellis (1997) reports coho salmon juveniles were also observed in Ryan Creek. Coho salmon were not observed during recent surveys of Bloody Run, Long Valley, Rowes, Reeves, and Haehl creeks (all tributaries to Outlet Creek) (CDFG unpubl. data).

No coho salmon were observed during recent surveys of smaller Eel River tributaries such as Price, Atwell, Dinner, Jordan, Shively, Bear, Chadd, Larabee (and its tributary Carson Creek), Newman, Bluff (tributary to the North Fork Eel River), and Kekawaka creeks, and Tomki Creek tributaries Rocktree, String and Tartar creeks (CDFG unpubl. data).

At the Van Arsdale Fish Station, one adult coho salmon was seen in 2000 and three have been observed through December 7, 2001 (Alan Grass, pers. comm.).

Records indicate coho salmon were more widespread in the Eel River basin in the past. Coho salmon were once present in the North Fork Eel River and its tributary Bluff Creek. They were also present in the Middle Fork Eel and its tributaries Rattlesnake, Mill, Grist, and Rock creeks (CDFG 1994a). Coho salmon in the North Fork and Middle Fork Eel are now believed to be extirpated (Brown and Moyle 1991; CDFG 1994a). Coho salmon were noticeably absent during recent surveys of many of the tributaries to the Van Duzen River, in contrast to older surveys conducted on those same streams. Similarly, recent surveys failed to find coho salmon in many of the smaller tributaries to the Eel River where coho salmon had been reported historically. Although coho salmon were recently confirmed in many of the South Fork Eel River tributaries, there were nearly as many streams in which coho salmon were not observed.

Miscellaneous Mendocino County Coastal Streams

Historical Distribution: Brown and Moyle (1991) list historical runs of coho salmon in 43 small streams along the Mendocino County coast. Other coho salmon status reviews have listed from 22 to 74 streams as historically containing populations (Brown et al. 1994; Adams et al. 1999; NMFS 2001a).

Current Distribution: The most persistent coho salmon populations in these smaller watersheds have been located within the Cottoneva, Pudding, Hare, Caspar, Little River, Albion, and Big Salmon watersheds. Recently, coho salmon have been either completely absent or have been represented very sporadically within the Whale Gulch, Jackass (Wolf), Usal, Hardy, Juan, Russian Gulch, Buckhorn, Greenwood, Mallo Pass, Elk, Brush, Garcia, Schooner Gulch, or Fish Rock Gulch watersheds.

Ten Mile River (Mendocino County)

Historical Distribution: Recent status reviews on coho salmon distribution place the number of streams historically containing coho salmon in the Ten Mile River watershed at between eight and 18 (Brown and Moyle 1991; Brown et al. 1994; Adams et al. 1999; NMFS 2001a). The discrepancy in the number of streams reflects of the availability of records at the time of reporting, the ephemeral nature of this watershed with respect to availability of habitat,

and how distribution has been reported in the past. In 1963, there was an estimated 103 miles of coho salmon habitat within the Ten Mile River watershed (CDFG 2001b).

Coho salmon migration has periodically been impeded by natural events and anthropogenic factors within this watershed. In 1976, and from 1978 to 1982, drought was a notable impediment to fish migration and thus distribution within the watershed (CDFG 2001a). Coho salmon distribution over time has most likely been influenced by logging activities, especially by the formation of log jam barriers. In 1961, no less than 13 stream survey reports recommended removal of log jams that were acting as fish passage barriers (CDFG 1961).

Current Distribution: Since the mid 1990s, fisheries surveys have revealed a spotty distribution of coho salmon within the historical Ten Mile River coho salmon streams (CTM 2001; GP 1997; Maahs 1996, 1997; NMFS 2001a). Coho salmon have been recently documented in nine of the 11 tributaries listed by Brown and Moyle (1991). Mill Creek and Redwood Creek are the only historical tributaries where coho salmon were not observed in 2001.

Noyo River (Mendocino County)

Historical Distribution: Reported distribution of coho salmon has ranged from 12 to 25 streams within the Noyo River watershed (Brown and Moyle 1991; Brown et al. 1994; Adams et al. 1999; NMFS 2001a). The differences in the number of streams reported as once supporting coho salmon is most likely a combination of several factors, including past reporting methods, drought, and barriers hindering passage throughout the watershed. The Noyo River harbor has eliminated the initial problem of access to the river experienced during drought conditions.

The Department conducted many stream surveys in the 1950s and 1960s, similar to the surveys conducted in other coastal watersheds in Mendocino County. Many of the survey reports cataloged log jams and barriers, which may have contributed to fish passage problems (CDFG 1957, 1959, 1966). The Department has maintained a coho salmon egg collecting station on the South Fork Noyo River since 1962 and coho salmon have been reported at that facility every year since 1962 (CDFG 2001a). The egg collecting station, flashboard dams at the Parlin Fork Conservation Camp on the South Fork Noyo, and the Boy Scout camp on the mainstem Noyo River may have caused passage problems during drought conditions. These persistent structures may also be problematic for juvenile migration (NMFS 2001b). A dam that impounds McGuire's Pond on the South Fork Noyo River was built in the early 1900s and has eliminated approximately 1.5 miles of salmonid habitat.

Current Distribution: Coho salmon persist throughout much of the Noyo River watershed. Since the ESA listing of coho salmon in the mid 1990s, surveys and monitoring efforts have increased within this watershed (CTM 2001; Harris 2000a, 2000b; MRC 1999; Valentine and Jameson 1994). Eight of the 12 streams identified by Brown and Moyle (1991) as historical coho salmon streams were surveyed in 2001 and coho presence was detected in all but the Middle Fork of the North Fork Noyo River.

Big River (Mendocino County)

Historical Distribution: Previous reports list the number of streams historically containing populations of coho salmon in the Big River watershed as ranging from 14 to 23

streams (Brown and Moyle 1991; Brown et al. 1994; Adams et al. 1999; NMFS 2001a). All main branches of Big River have supported populations of coho salmon. There were approximately 101 stream miles considered to be coho salmon habitat in 1963 (CDFG 2001b). Stream surveys conducted by the Department in 1959 suggest the most common reason for poor distribution of coho salmon was the numerous log jam barriers (CDFG 1959). Many of these barriers persisted into the 1960s and some were still present into the 1980s.

Current Distribution: Surveys conducted since the mid-1990s reveal a spotty distribution with coho salmon documented more consistently in the North Fork tributaries than the remainder of the watershed. Most of the 16 streams listed by Brown and Moyle (1991) as historically containing coho salmon are either within Jackson State Forest (North Fork Big River) or within property owned and managed by Mendocino Redwood Company. Recently, 15 of the 16 historical streams were surveyed and coho salmon were documented in nine streams (60%): mainstem Big River, Little North Fork Big River, Berry Gulch, Two Log Creek, North Fork Big River, East Branch North Fork Big River, Chamberlain Creek, Arvola Gulch, and James Creek (CDFG unpubl. data).

Navarro River (Mendocino County)

Historical Distribution: Reported distribution of coho salmon has ranged from 15 to 28 streams within the Navarro River watershed (Brown and Moyle 1991; Brown et al. 1994; Adams et al. 1999; NMFS 2001a). CDFG (2001b) estimated approximately 130 miles of coho salmon stream habitat were present in 1963. Logging, cattle grazing, drought, and more recently viticulture, have impacted coho salmon distribution within this watershed. Drought and low flow conditions have also affected both salmonid distribution and production. Most of these surveys conducted by the Department in the late 1950s and 1960s reported numerous log barriers caused by accumulated debris from historical logging activities (CDFG 1957, 1959, 1966). These barriers likely limited distribution and overall production of coho salmon.

Current Distribution: The present distribution of coho salmon within the Navarro River watershed is substantially less than that recorded historically. Fourteen of the 19 streams listed by Brown and Moyle (1991) as historical coho salmon streams were surveyed in 2001. Coho salmon were observed in only six of these streams: mainstem Navarro River, Flynn Creek, South Branch of the North Fork, North Branch of the North Fork, Little North Fork, and John Smith Creek (CDFG unpubl. data). Presence of coho salmon was higher in North Fork tributaries than in the remainder of the watershed. Coho salmon populations are now restricted to the western portion of the watershed.

Albion River (Mendocino County)

Historical Distribution: Brown and Moyle (1991) and Adams et al. (1999) list five and eight streams, respectively, as historically containing coho salmon populations. The increase in the number of streams is directly related to information supplied by Louisiana Pacific in the early and mid-1990s. Since the building of the harbor, sand bar closure no longer inhibits passage during drought years.

Current Distribution: Although coho salmon runs were stronger in the past, runs persist to this day. Brown and Moyle (1991) list the mainstem and four tributaries within the watershed

as historical coho salmon streams. In 2001, three of the four streams were surveyed and coho salmon were found in all three streams. Several other tributaries including Deadman Gulch, Railroad Gulch, Pleasant Valley Gulch, Duckpond Gulch, East Railroad Gulch, Tom Bell Creek, and unnamed tributaries to Marsh Creek, have been identified as supporting coho salmon since 1995 (LP 1996; MRC 2000).

Garcia River (Mendocino County)

Historical Distribution: Brown and Moyle (1991) and Adams et al. (1999) list one and three streams, respectively, as containing historical runs of coho salmon populations. Coho salmon presence has been established sporadically in the past few decades (CDFG 1967, 1968, 1989). In the late 1960s, stream surveys were conducted by the Department throughout much of the Garcia River watershed. Similar surveys conducted within other Mendocino County watersheds at approximately the same time identified logging and its effects as the main issues limiting distribution and production of coho salmon (CDFG 1967, 1968). An estimated 38 miles of coho salmon habitat exist within the Garcia River watershed (CDFG 2001b).

Current Distribution: Only the mainstem of the Garcia River was identified by Brown and Moyle (1991) as an historical coho salmon stream, but NMFS (2001a) also identified the South Fork and Fleming Creek (tributary to the South Fork) as historical coho salmon streams. Surveys conducted on these three streams since 1989 have detected coho salmon presence only in the South Fork Garcia River 1994 and 1996 (MRC 1999).

Gualala River (Mendocino and Sonoma Counties)

Historical Distribution: Reported historical distribution of coho salmon has ranged from 10 to 15 streams within the Gualala River watershed (Brown and Moyle 1991; Brown et al. 1994; Adams et al. 1999; NMFS 2001a). There is an estimated 75 miles of coho salmon habitat within the watershed (CDFG 2001b).

In the mid-1970s, the Department's Coastal Steelhead Project was conducted, in part, on the Gualala River. During the life of this project, several types of fish surveys were conducted. Between 1973 and 1976, at least 33 adult coho salmon were counted during creel census surveys on the mainstem of the Gualala River (CDFG 1973, 1974, 1975, 1976). In 1963, coho salmon escapement was estimated at 4,000 fish.

Stream surveys have reflected poor distribution of coho salmon throughout the Gualala River watershed. Logging activities have been identified as impacting distribution, mainly through barrier formation (CDFG 1952, 1964). Coho salmon were reported in Marshall and Fuller Creeks in 1964 and coho salmon were again found in Marshall Creek in 1970 (CDFG 1964, 1970). Coho salmon were also reported in the North Fork and Little North Fork Gualala River (CDFG 1964).

Current Distribution: The present distribution of coho salmon is drastically different from historical accounts in this watershed. Ten of the eleven historical coho salmon streams listed by Brown and Moyle (1991) were surveyed in 2001 and coho salmon were not observed in any of the streams. Since 1995, presence of naturally produced coho salmon has only been documented in Robinson and Dry creeks (both are tributary to the North Fork) (GRI 2001). Neither Robinson or Dry creeks were listed by Brown and Moyle (1991) as historically containing coho salmon. Both of

these streams were surveyed in 1999, 2000, and 2001 and no coho salmon were found (CDFG unpubl. data). There are now no known remaining viable coho salmon populations in the Gualala River system.

A total of 45,000 juvenile coho salmon, from 1995-1997 brood years, was planted in the Little North Fork Gualala River over three years. The juveniles were the products of the Noyo River Egg Collecting Station run by the Department. Subsequent surveys through the year 2000 have revealed no adult returns.

Miscellaneous Sonoma County Coastal Streams

Historical Distribution: Brown and Moyle (1991) listed 10 streams as historically containing coho salmon. These streams are located within four watersheds: Fort Ross Creek, Russian Gulch, Scotty Creek, and Salmon Creek.

Current Distribution: Coho salmon have not been observed in any of these watersheds in recent years (CDFG unpubl. data).

Russian River (Sonoma and Mendocino Counties)

Historical Distribution: Reported historical distribution of coho salmon has ranged from 29 to 46 streams within the Russian River watershed (Brown and Moyle 1991; Brown et al. 1994; Adams et al. 1999; NMFS 2001a). SEC (1996) stated the distribution of coho salmon is much reduced from its historical range and that coho salmon once inhabited streams throughout portions of the watershed, from the lower mainstem tributaries upstream to the tributaries of the West Fork.

Coho salmon distribution within the Russian River watershed has been affected by dams, augmented flows, introduced fishes, gravel mining, sport and commercial harvest, land use practice (logging, road building, agriculture, urbanization), and an increase in hatchery production (SEC 1996). The overall conversion of this watershed from its natural state has led to a fishery dominated by introduced and warmwater species. Of the 48 fish species known to inhabit the Russian River, 29 have been introduced.

Current Distribution: Data collected recently indicates that there has been a catastrophic reduction in coho salmon distribution in the Russian River system. During field surveys conducted in 2001, 29 of the 32 streams listed by Brown and Moyle (1991) as historical coho salmon streams were surveyed. Coho salmon were found in only one of these streams (Mark West Creek). Additional surveys conducted in 2001 found coho salmon in Green Valley Creek and Redwood Creek, neither of which were listed by Brown and Moyle (1991). All of these streams are in the lower portion of the Russian River basin.

During 287 electrofishing and 58 spawning surveys in the Russian River over seven field seasons, only 79 coho salmon juveniles and one coho salmon carcass were observed (Coey 2000). Twenty three of the juveniles were found in a single year in one place (Mill Creek, tributary to Dry Creek, Sonoma County).

Several historical coho salmon streams are now located upstream of dams. Rocky, Mariposa, Fisher, and Corral creeks are located above Mumford Dam, which will soon be retrofitted to allow

anadromous fish passage. The roughs near the mouth of Mill Creek, a tributary to Forsythe Creek, most likely preclude use of that tributary by coho salmon.

Miscellaneous Marin County Coastal Streams

Historical Distribution: The 10 streams listed by Brown and Moyle (1991) as historical coho salmon streams are located within four watersheds: Walker, Lagunitas, Pine Gulch, and Redwood creeks.

At one time, Walker Creek supported a good return of coho salmon (Worsely 1972) but there are very few recent records of coho salmon in that creek. Emig (1984) recorded at least eight species of fish, including coho salmon, during a survey in 1981. Water diversion activities may have affected conditions in Redwood Creek, most likely impacting distribution of coho salmon (Snider 1984; Arnold 1971). Coho salmon were observed there sporadically from 1956 to 1996 (CDFG 1956, 1976, 1977, 1984; Smith 1998).

Major tributaries to Lagunitas Creek are Olema, Nicasio, Devil's Gulch, and San Geronimo creeks. Surveys indicate that all of these tributaries have contained coho salmon populations (CDFG 1986; Trihey & Assoc., Inc. 1995). Marin Municipal Water District, the largest water user in the watershed, operates Lagunitas, Bon Tempe, Kent, and Alpine reservoirs on the mainstem and Nicasio Reservoir on a tributary. The five reservoirs have eliminated almost half of the once available anadromous habitat

Current Distribution: Recently, coho salmon were observed in Pine Gulch Creek in 1997 and 2001, but not in 1998 and 1999 (Brown et al. 1998, 1999; NPS 2001). Very few surveys have been conducted in the past decade within the Walker Creek watershed, and those that have been conducted have not found coho salmon. Coho salmon are still extant in Redwood Creek (Smith 2000; Bill Cox, pers. comm.).

Coho salmon have been observed consistently for the past decade within the Lagunitas Creek watershed, despite the numerous dams and subsequent loss of habitat. Lagunitas Creek and all of its tributaries, except probably Nicasio Creek, still contain coho salmon. The current estimated number number of spawners is about 800 adults annually (Bill Cox, pers. comm.).

San Francisco Bay Tributaries (Marin, Sonoma, Solano, Contra Costa, Alameda, Santa Clara, San Mateo, and San Francisco Counties)

Historical Distribution: Brown and Moyle (1991) list six Bay Area streams as historically containing coho salmon: Alameda, San Pablo, Walnut, San Anselmo, Corte Madera, and Mill Valley creeks. Other streams believed to have had historical runs of coho salmon include Strawberry, San Leandro, Sonoma, Arroyo Corte Madera del Presidio, and Coyote creeks (Leidy and Becker 2001). In 1969, and during the winter season of 1985/86, coho salmon were observed in Corte Madera Creek (CDFG 1969; Emig 1986; Leidy 1981). Undoubtedly, the effects of urbanization throughout the Bay Area have been the leading factor in the loss of salmonid populations and habitat.

Current Distribution: Prior to 1992, very few surveys were conducted on the fisheries of Bay Area tributaries. Coho salmon were not observed in periodic surveys conducted by East Bay Municipal Utility District fishery biologists in Pinole and San Leandro creeks from 1995 through

2001 (Jose Setka, pers. comm.). Leidy (1999) conducted fisheries surveys on 79 Bay Area streams between 1992 and 1998, and coho salmon were not observed in any of the surveys. The last known observation of coho salmon was in 1981, consequently, it is believed that coho salmon populations are now extinct in San Francisco Bay tributaries (Leidy and Becker 2001).

Presence-by-Brood-Year Investigation

Brown and Moyle (1991) identified 582 historical California coho salmon streams, 569 of which were north of, or tributary to, San Francisco Bay. Of the 235 streams for which there was recent information, coho salmon presence could be documented in only 130 streams (55%) (Table 5). Their analysis indicated that the proportion of streams that appeared to have lost their coho salmon populations increased from north to south. In Del Norte County, 45% of the streams for which there are reliable records had lost their coho salmon populations, mainly in the Klamath-Trinity river system. In Humboldt, Mendocino, and Sonoma counties, the proportion of historical streams that no longer appeared to contain coho salmon populations was 31% , 41%, and 86%, respectively (Table 5). When Del Norte and Humboldt County streams were combined, coho salmon were present in 73 (63%) of the historical streams where recent information existed regarding coho salmon distribution (Brown and Moyle 1991).

The Department's presence-by-broodyear investigation found four discrepancies in the historical coho salmon streams identified by Brown and Moyle (1991): some streams were listed twice, one stream was located above a barrier, and one stream that was listed because coho salmon were planted but did not result in adult returns, which violated one of their criteria for inclusion as a historical stream (see Brown and Moyle [1991] for a description of their criteria). Therefore, for purposes of this review, the 396 historical coho salmon streams north of Punta Gorda identified by Brown and Moyle (1991) was reduced to 392.

In addition, Department staff found considerable additional documentation on the 392 historical coho salmon streams of Del Norte, Humboldt, Trinity, Siskiyou, and northern Mendocino counties (which coincides with the California portion of the SONCC Coho ESU), increasing the number of streams with information from 115 as reported in Brown and Moyle (1991) to 235 for brood years 1986 through 1991. Of these 235 streams, coho salmon presence could be detected in 143 streams (61%) (Table 5). This does not appear to be appreciably different from the 63% presence as reported by Brown and Moyle (1991) for these streams despite the additional documentation.

More recent information on brood years 1995 through 2000[10] was found for 355 of the Brown and Moyle (1991) historical coho salmon streams in Del Norte, Humboldt, Trinity, Siskiyou, and northern Mendocino counties. Of the 355 streams for which there are recent data, presence of coho salmon could not be detected in 176 (50%) of the streams (Table 5). This proportion is not directly comparable with that of the 1986 through 1991 time frame (61%) used by Brown and Moyle (1991) because not necessarily the same streams were included in the analysis. When only those streams with information that are common to both time frames are considered (223 streams), then the number of streams where presence can be detected is 62% for the 1986 -1991 period vs. 57% for the 1995-2000 period. Both Pearson chi square and Yates corrected chi square tests indicated that the difference is not statistically significant (p= 0.228 and 0.334, respectively).

[10] The length of this time period was chosen to include two brood-year cycles and to facilitate comparison with the time period used by Brown and Moyle (1991) that is of similar length.

Table 5. Historical presence of coho salmon north of San Francisco, as determined by Brown and Moyle (1991) and the Department's presence-by-brood-year investigation (as of February 2002). County classifications are based on the location of the mouth of the river system. Dash line indicates analysis was not done.

	Brown & Moyle Calendar years 1987 through 1990					Coho Presence as Determined by CDFG Investigation Brood years 1986 through 1991					Coho Presence as Determined by CDFG Investigation Brood years 1995 through 2000				
	No. of streams	No. of streams w/ info.	Coho Present	(%)	Coho Absent	No. of streams	No. of streams w/ info.	Coho Present	(%)	Coho Absent	No. of streams	No. of streams w/ info.	Coho Present	(%)	Coho Absent
DEL NORTE COUNTY															
Coastal	9	1	1		0	8	5	3		2	8	8	6		2
Smith River	41	2	2		0	41	21	7		14	41	39	14		25
Klamath River	113	41	21		20	112	82	48		34	112	89	55		34
Subtotal	163	44	24	(54%)	20	161	108	58	(53%)	50	161	136	75	(55%)	61
HUMBOLDT COUNTY															
Coastal	34	7	7		0	33	16	14		2	33	32	18		14
Redwood Creek	14	3	3		0	14	12	12		0	14	14	11		3
Mad River	23	2	2		0	23	10	8		2	23	22	14		8
Eel River	124	56	34		22	123	80	48		32	123	116	45		71
Mattole River	38	3	3		0	38	9	3		6	38	35	16		19
Subtotal	233	71	49	(69%)	22	231	127	85	(67%)	42	231	219	104	(47%)	115
Subtotal: Del Norte & Humboldt Counties	396	115	73	(63%)	42	392	235	143	(61%)	92	392	355	179	(50%)	176
MENDOCINO COUNTY															
Coastal	44	35	13		22	-	-	-		-	-	-	-		-
Ten Mile River	11	10	7		3	-	-	-		-	-	-	-		-
Noyo River	13	12	11		1	-	-	-		-	-	-	-		-
Big River	16	13	11		2	-	-	-		-	-	-	-		-
Navarro River	19	8	4		4	-	-	-		-	-	-	-		-
Subtotal	103	78	46	(59%)	32	-	-	-		-	-	-	-		-
SONOMA COUNTY															
Coastal	10	2	1		1	-	-	-		-	-	-	-		-
Gualala River	11	2	1		1	-	-	-		-	-	-	-		-
Russian River	32	24	2		22	-	-	-		-	-	-	-		-
Subtotal	53	28	4	(14%)	24	-	-	-		-	-	-	-		-
MARIN COUNTY															
Coastal	10	7	7		0	-	-	-		-	-	-	-		-
Subtotal	10	7	7	(100%)	0	-	-	-		-	-	-	-		-
TRIBUTARIES TO S.F. BAY															
Coastal	7	7	0		7	-	-	-		-	-	-	-		-
Subtotal	7	7	0	(0%)	7	-	-	-		-	-	-	-		-
Total	569	235	130	(55%)	105	392	235	143	(61%)	235	392	355	179	(50%)	176

In contrast, analyses by NMFS (2001a; and peer review comments in Appendix B2) on ungrouped annual presence data show declines in the probability of detecting coho between 1989-2000 in the California portion of the SONCC Coho ESU. Also, in the CCC Coho ESU, NMFS found that increasing trends in coho detectability are confounded by variation in sampling effort between 1989 and 2000. Based on their most recent analysis, NMFS (2001a) concludes that the ability to detect coho is declining in the north, is lower in the south than in the north, and apparent trends in the south are confounded by changes in sampling effort between 1989-2000.

2001 Presence Survey Information

Southern Oregon/Northern California Coast Coho ESU

Of the 396 streams that were identified by Brown and Moyle (1991) as historically supporting coho salmon within the SONCC Coho ESU, 287 were surveyed in 2001 to determine if coho salmon presence could be detected. Of the 287 streams surveyed, presence of coho salmon was confirmed in 121 (42%) streams; conversely, presence of coho salmon was not confirmed in 166 (58%) streams (Table 6). Presence of coho salmon ranged from 100% in the Little River drainage (n=4) to 0% in the Bear River drainage (n=4). In the Eel River drainage, presence of coho salmon could be detected in 32 (27%) of the 117 streams surveyed (Table 6). Results of the presence surveys are shown in Figures 7, 8, 9, 10 and 11.

It should be noted that "presence not detected" for a particular stream does not necessarily mean that coho salmon have been extirpated. In some instances, only one reach of a sampled stream was surveyed, and coho salmon may have been present in those reaches not surveyed. Also, because coho salmon have a three-year life cycle, the inability to document one cohort (in this case, the 1999 or 2000 BYs) does not mean that other cohorts are missing, but would not be detected until surveys are done in subsequent years. Also, a single year's data from surveys may reflect adverse climatic or ocean conditions and not be completely representative of the population as a whole. For example, 2001 was classified as a drought year on the north coast, and this undoubtedly affected distribution to a greater degree than if it were a normal, above normal, or wet year.

On 110 (66%) of the 166 streams where presence could not be detected, sampling was considered to be intensive enough to detect coho salmon populations if they had been present in the stream. For these streams, surveys were done in at least two of three reaches (lower, middle, upper) following the "Modified Ten-Pool Protocol" methodology (Appendix C1), or were surveyed in only one reach because the other two reaches were inaccessible to coho salmon (because of either a barrier to migration or the other reaches were dry), or were not surveyed at all because the entire stream was dry. Although this does not show conclusively that coho salmon are absent from these streams, this high level of sampling effort indicates that coho salmon were likely not present in the stream, or that population size is so low that coho salmon were not detectable by standard survey methods.

Central California Coast ESU

Of the 173 streams listed by Brown and Moyle (1991) as historically supporting coho salmon populations within the CCC Coho ESU, 135 were surveyed during 2001 by the Department and other organizations (Table 7). Of the streams surveyed, presence was confirmed

in 43 streams, and not confirmed in 92 streams. The percentage of streams within a basin with confirmed presence ranged from 88% (n=8) in the Noyo River basin to 0% for the Gualala River basin (n=10).

In addition to the 2001 surveys, 23 streams surveyed between 1995 and 2000 were assumed to have extant populations of coho salmon because they were found in three consecutive years during this period. Combining the 2001 survey results with the assumed presence of coho salmon, Mendocino County streams had a greater coho salmon presence in historical streams than the watersheds to the south. In Mendocino County, coho salmon were present in 58 (62%) of 93 streams that were surveyed or were assumed to have coho salmon present. To the south of Mendocino County, only eight (12%) of the 65 historical streams surveyed, or assumed to have coho salmon, contained them (Table 7). Results of the Department's 2001 presence surveys are shown in Figures 12 and 13).

Table 6. Results of the Department's 2001 coho salmon presence surveys of SONCC Coho ESU streams listed by Brown and Moyle (1991) as historically containing coho salmon. Appendix C2 lists streams surveyed in 2001 by the Department.

Basin	No. of streams surveyed	No. of streams with coho present (%)	No. of streams with coho presence not detected
Smith River	37	14 (38%)	23
Klamath River	25	17 (68%)	8
Redwood Creek	14	11 (79%)	3
Little River	4	4 (100%)	0
Mad River	21	12 (57%)	9
Humboldt Bay	18	12 (67%)	6
Eel River	117	32 (27%)	85
Bear River	4	0 (0%)	4
Mattole River	31	9 (29%)	22
Other Coastal	13	6 (46%)	7
Total Streams Surveyed:	**284**	**117 (41%)**	**167 (59%)**

Table 7. Results of the coho presence surveys in streams listed by Brown and Moyle (1991) as historically containing coho salmon for CCC Coho ESU streams. Appendix C2 lists streams surveyed in 2001 by the Department.

	No. of streams surveyed in 2001 (A)	No. of streams with coho present in 2001 (B)	No. of streams with coho assumed present [e] (C)	No. of streams w/ coho not detected in 2001	Percent present (1995 - 2001) [f]
MENDOCINO COUNTY					
Coastal	30	11	10	19	52%
Ten Mile River	11	9	-	2	82%
Noyo river	8	7	5	1	92%
Big River	8	3	6	5	64%
Navarro River	14	6	1	8	47%
Subtotal	71	36	22	35	62%
SONOMA COUNTY					
Coastal	4	0	-	4	0%
Gualala River	10	0	-	10	0%
Russian River	29	1	1	28	7%
Subtotal	43	1	1	42	4%
MARIN COUNTY					
Coastal	5	2	-	3	40%
Salmon Creek	5	0	-	5	0%
Lagunitas Creek	5	4	-	1	80%
Subtotal	15	6	-	9	40%
TRIBUTARIES TO S.F. BAY					
Coastal	6	0	-	6	0%
Subtotal	6	0	-	6	0%
TOTAL	135	43	23	92	42%

[e] Coho salmon were assumed to be present if presence in three consecutive brood years was detected between 1995 to 2000. These streams were not surveyed in 2001.

[f] (B+C) / (A+C)

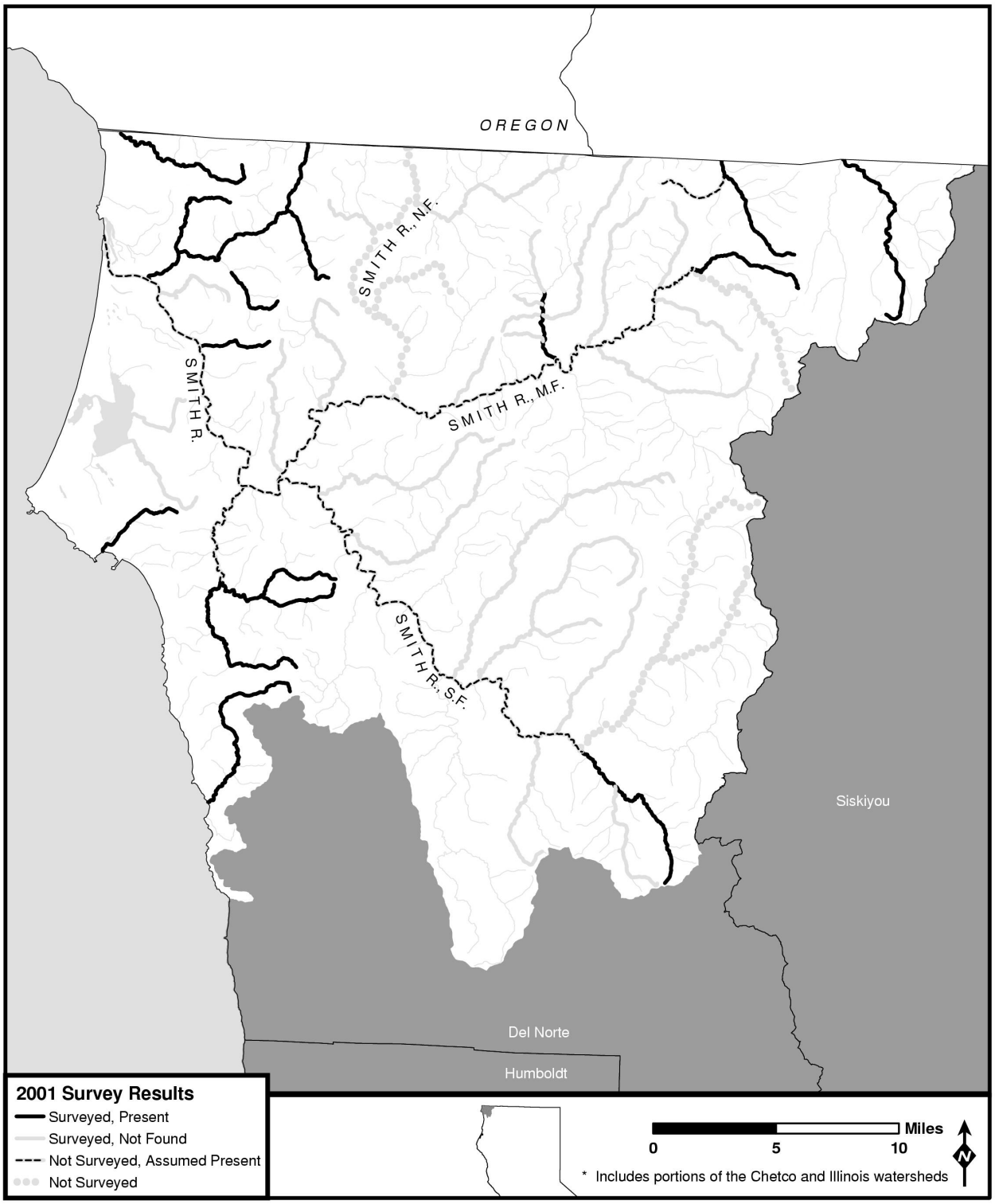


Figure 7. Results of the 2001 presence surveys in historical coho salmon streams (Brown and Moyle 1991) of the Smith River watershed. Includes portions of the Chetco River and Illinois River watersheds.

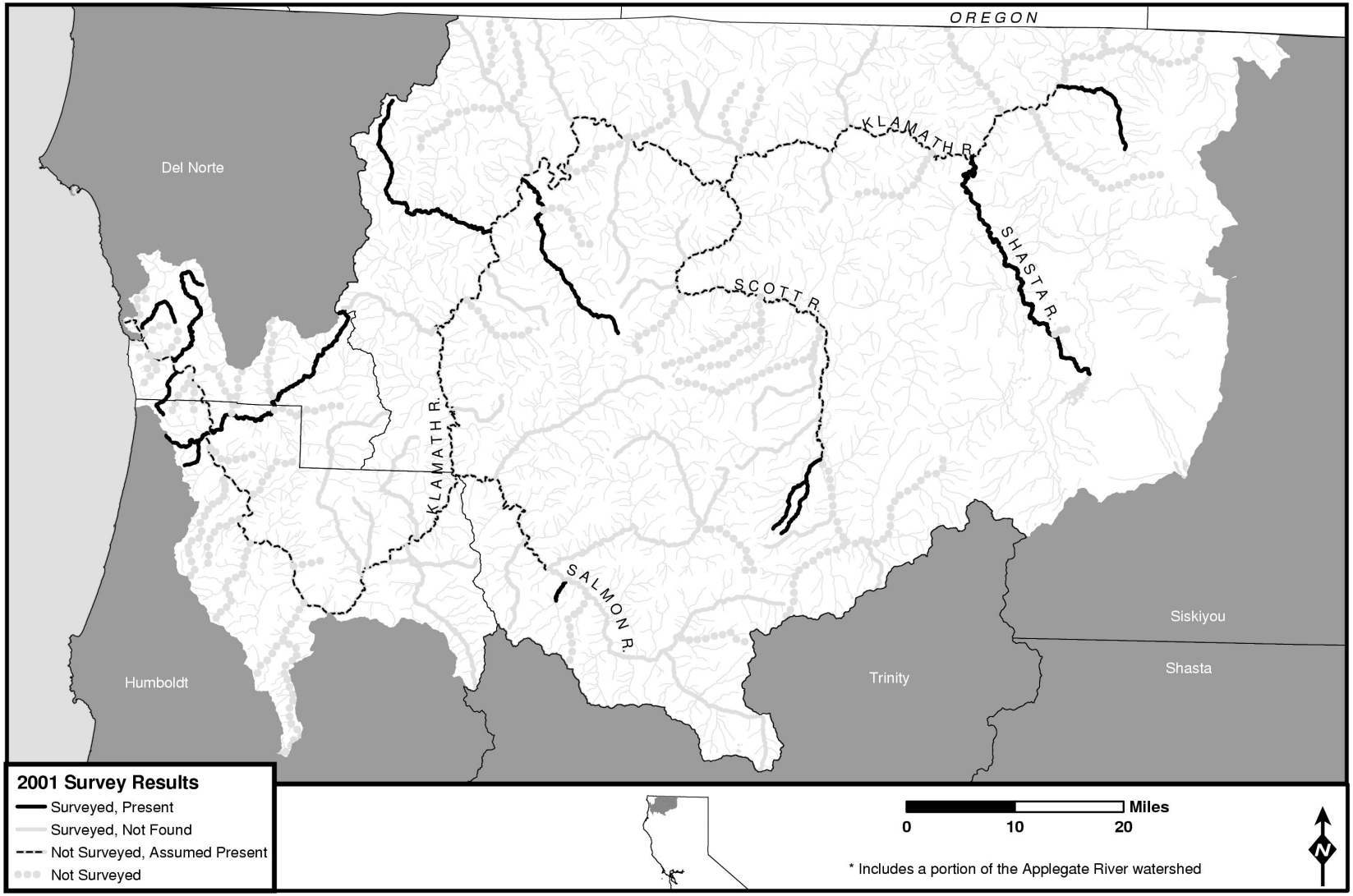


Figure 8. Results of the 2001 presence surveys in historical coho salmon streams (Brown and Moyle 1991) of the Klamath River watershed.

V. STATUS OF CALIFORNIA COHO SALMON POPULATIONS NORTH OF SAN FRANCISCO

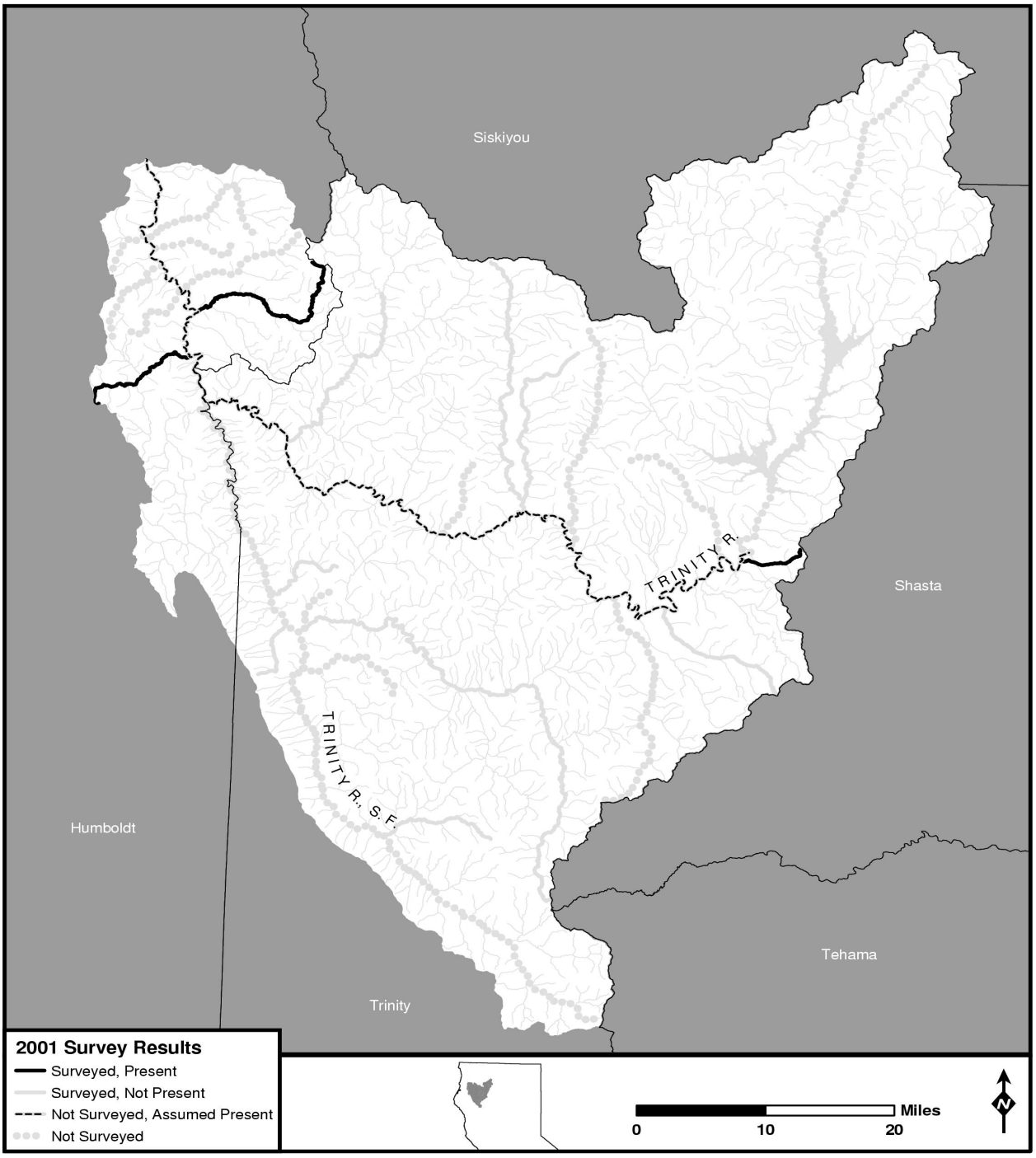


Figure 9. Results of the 2001 presence surveys in historical coho salmon streams (Brown and Moyle 1991) of the Trinity River watershed.

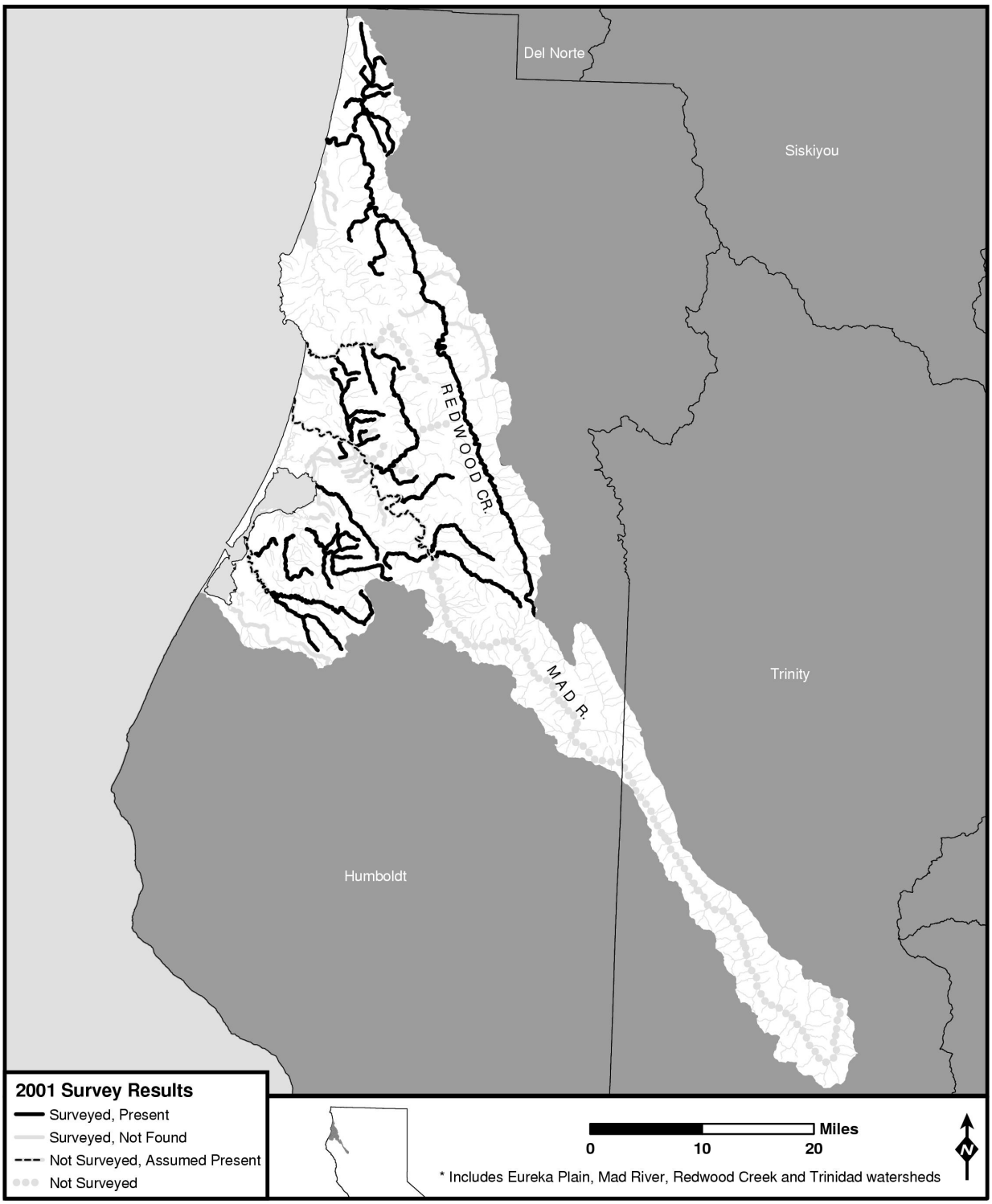


Figure 10. Results of the 2001 presence surveys in historical coho salmon streams (Brown and Moyle 1991) of the Redwood Creek, Mad River, Eureka Plain, and Trinidad watersheds.

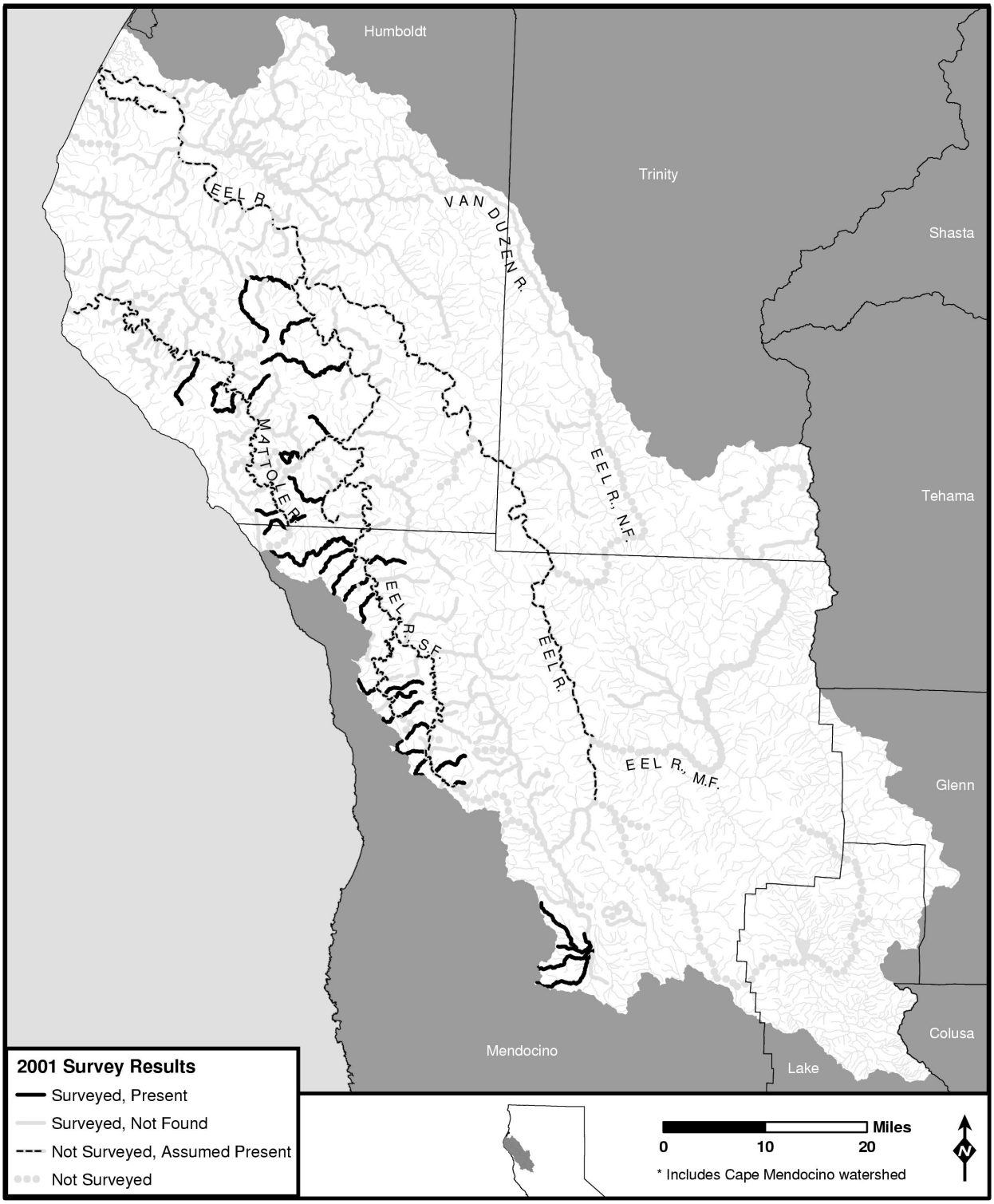


Figure 11. Results of the 2001 presence surveys in historical coho salmon streams (Brown and Moyle 1991) of the Eel River watershed.

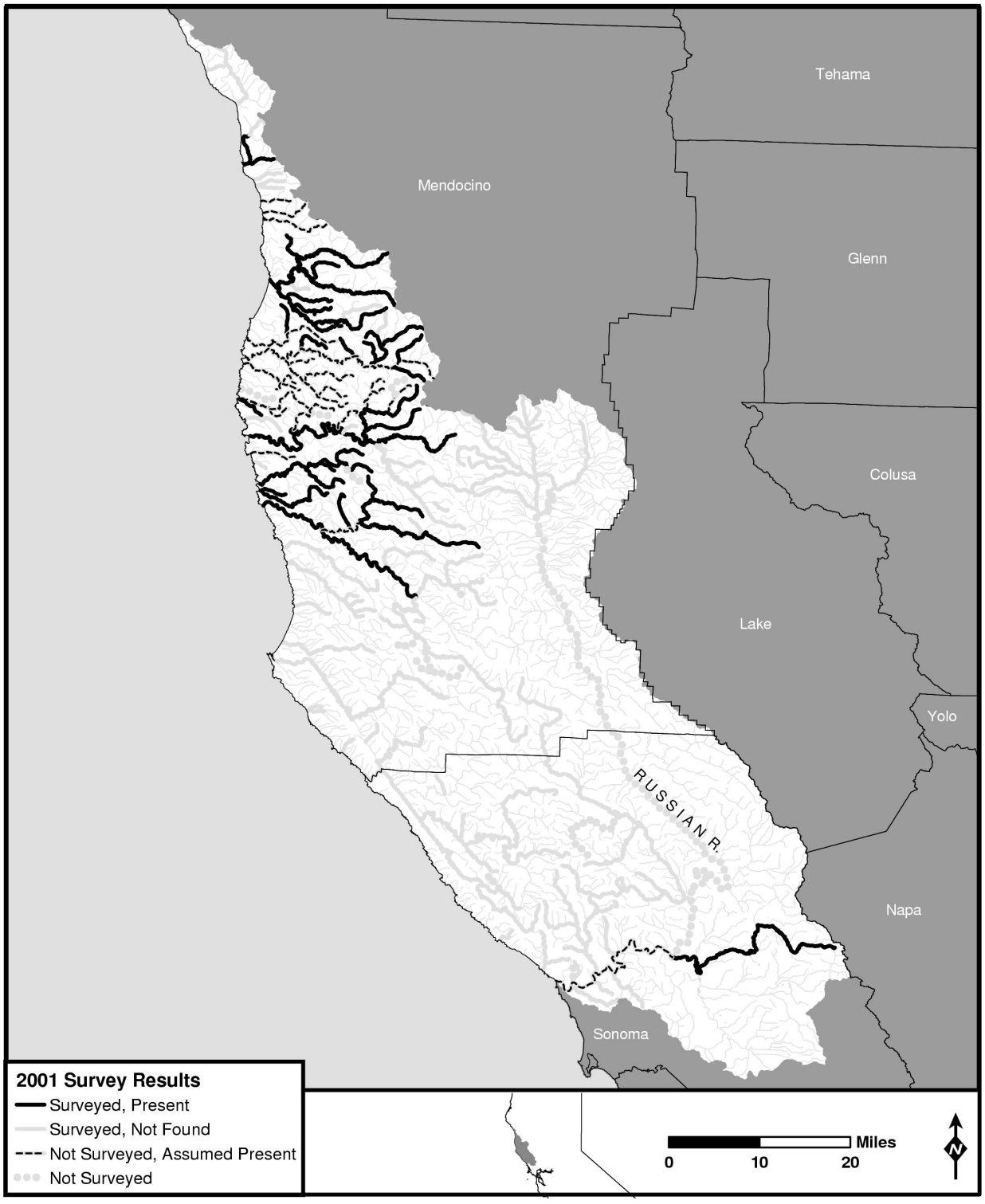


Figure 12. Results of the 2001 presence surveys in historical coho salmon streams (Brown and Moyle 1991) of Mendocino County coastal and Russian River watersheds.

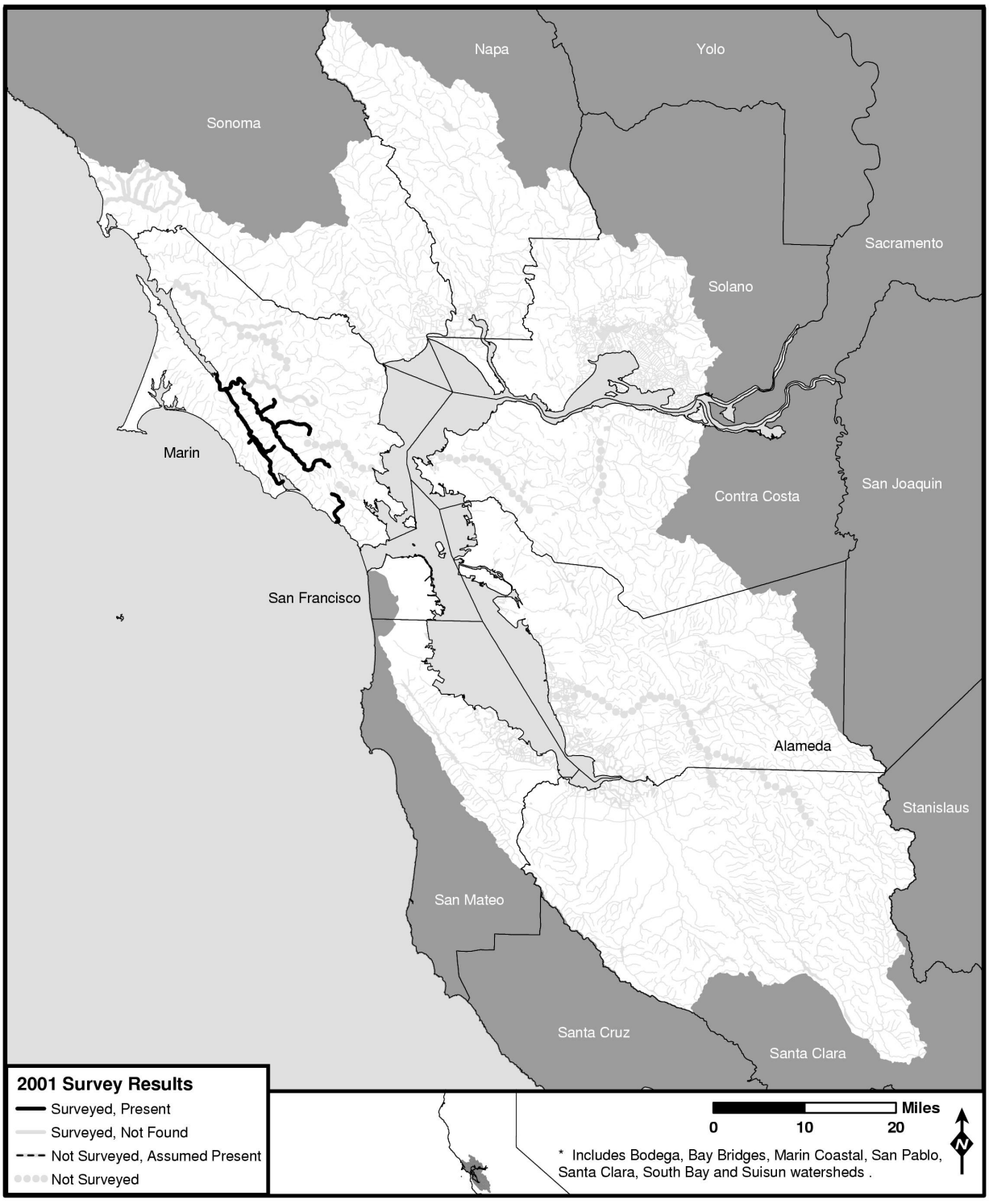


Figure 13. Results of the 2001 presence surveys in historical coho salmon streams (Brown and Moyle 1991) of Marin County and San Francisco Bay coastal watersheds.

Abundance and Trends

Historical assessments of coho salmon abundance are based on estimates made by fisheries managers from limited catch data, hatchery records, and personal observations (Brown et al. 1994). Historical population estimates and subsequent declines are not easy to document because the species is divided into many small populations of which very few are monitored closely (Brown et al. 1994). In the 1940s, there were estimated to be between 200,000 and 500,000 coho salmon spawning in California. The number of spawners decreased to about 100,000 in the 1960s, with 40,000 in the Eel River alone (CDFG 1965; Brown et al. 1994). In 1984-85 the statewide total of natural spawners was estimated at 30,480 (Wahle and Pearson 1987), 6% to 15% of the level in the 1940s.

Coho salmon were historically an important part of the ocean salmon catch. Commercial coho salmon landings totaled over 1.6 million pounds annually between 1976 and 1979 (data from NMFS 1977-1993, as cited in Brown et al. 1994). Increased hatchery production is correlated with the large catches of the 1960s and 1970s, and is probably responsible for them (Brown et al. 1994). However, the commercial catch dropped precipitously in the late 1970s despite continued large hatchery releases (Brown et al. 1994). Correlation analysis indicates that there is an inverse relationship between California hatchery production and commercial landings ($r = 0.65$; $p = 0.02$) from 1979 through 1990 (Figure 14)[11]. As hatchery production increased, commercial landings decreased, indicating that the decline in catch during this period is not due to reduction in hatchery production. Commercial catch dropped to less than 20% of 1976-79 levels (301,000 pounds annually) during the 1980s. Annual commercial and sport catch combined still totaled 83,000 coho salmon in the 1980s (Brown et al. 1994). The harvest of 11,000 pounds in 1992, the last year of coho salmon retention in the commercial fishery, was substantially lower than previous years (Brown et al. 1994). Catch per unit effort for the commercial fishery similarly plummeted in 1992 compared to previous years (Figure 15). Retention of coho salmon in the ocean recreational fishery has been prohibited for areas north of Horse Mountain, California since 1994, and coastwide since 1995.

Brown et al. (1994) compiled data on historical and current presence/absence, population size, and trends in abundance from a variety of sources and for numerous coho salmon streams. Their recent estimates covered the years 1987-91. They concluded at that time that California native stocks were at low levels and that the streams containing coho salmon were fewer compared to historical estimates. The authors stated that the methods employed likely overestimated population sizes, so documented declines are probably more severe than estimated. Among their specific findings are:

- The total number of coho salmon adults in California streams between 1987-91 is estimated to be an average of 31,000 per year, 57% of which are hatchery-origin fish.

- The total estimated number of non-hatchery adult coho salmon, including both naturalized and native wild stocks, returning to spawn between 1987-91 was about 13,000 per year.

[11] Figure 14 depicts California coho salmon production only and does not reflect Oregon coho salmon production. Oregon hatchery coho salmon are known to comprise a large portion of the ocean catch.

- Naturalized spawners with recent hatchery ancestry were estimated to number about 9,000 per year between 1987-91. This was 69% of the total natural-spawning stock.

- Native wild coho salmon are estimated to consist of less than 5,000 fish per year. Many of these were thought to exist in populations of less than 100 individuals per year.

- Coho salmon abundance is likely less than 6% of 1940s levels. There has been an estimated decline of at least 70% since the 1960s.

- California coho salmon populations will likely continue to decline.

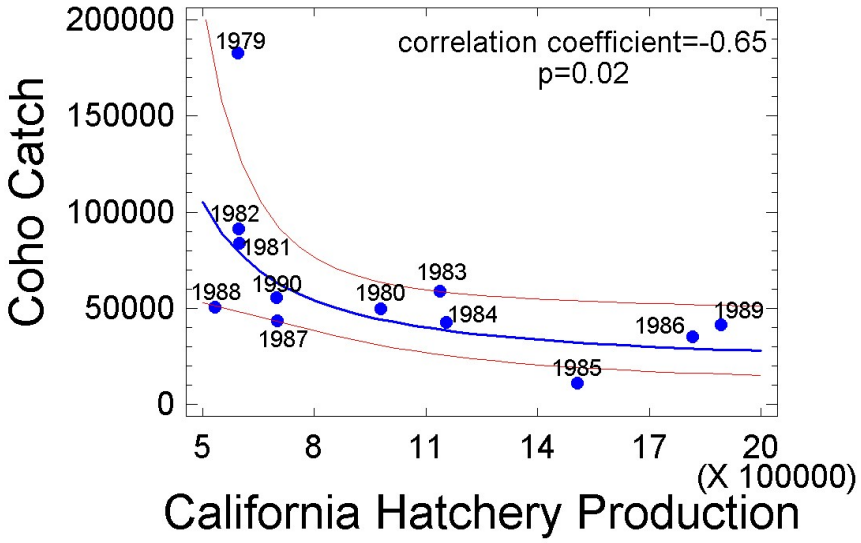
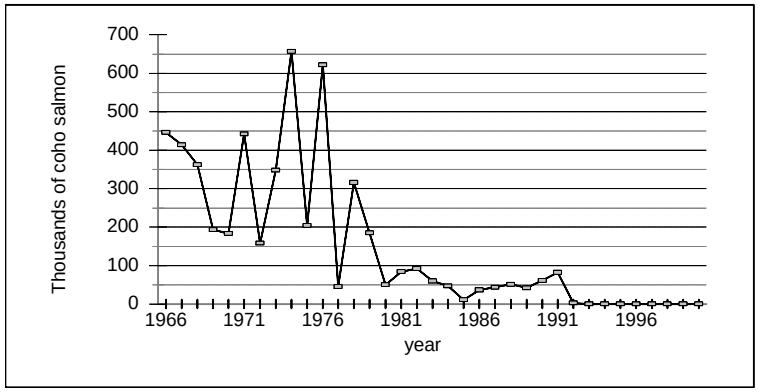
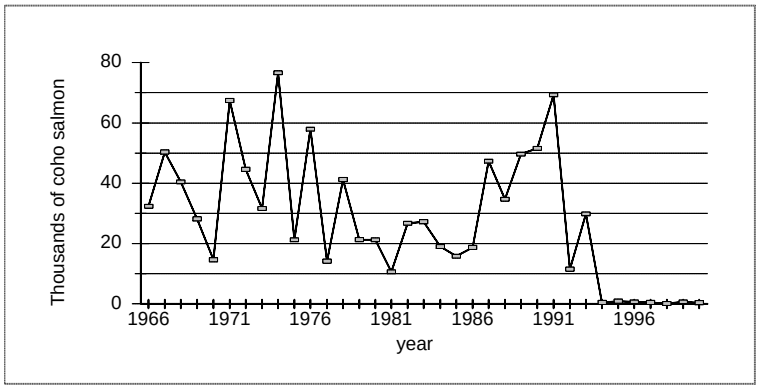


Figure 14. California coho salmon hatchery production of juveniles vs. commercial catch of adults two years later, 1979 to 1990. Both catch and production are numbers of fish. Catch is determined from landings at Crescent City, Eureka, Fort Bragg, and San Francisco. An S-curve model was used to fit the line.





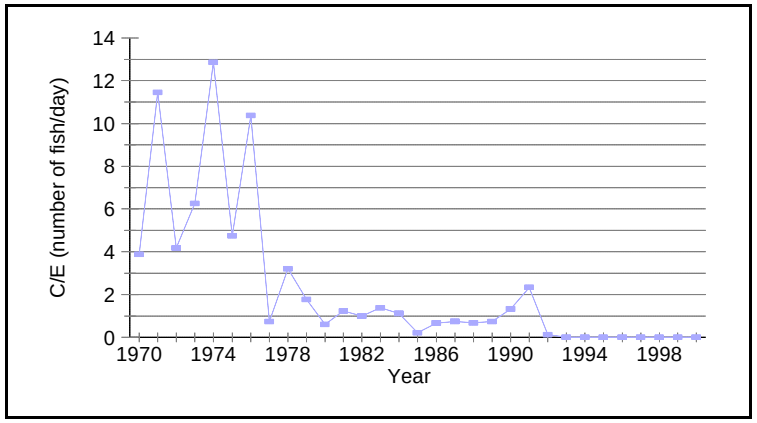


Figure 15. California commercial and ocean recreational coho salmon catch. Top graph is commercial ocean catch, 1966 to 2000; middle graph is recreational ocean catch, 1966 to 2000; and bottom graph shows number of coho salmon caught per day in California's commercial ocean salmon fishery, 1970-2000. The last year of commercial and ocean recreational coho salmon retention in California was 1992 and 1993, respectively.

Between 1987 and 1991, the estimated average coho salmon spawning escapement in the CCC Coho ESU was 6,160 natural-and 332 hatchery-spawned coho salmon. Of the naturally spawning fish, 3,880 were from tributaries with hatchery supplementation. Most of the fish in the remaining rivers were also judged as being influenced by hatchery stock and only 160 fish in this ESU were identified as native stock (Brown et al. 1994). The Eel River was estimated to have less than 1,000 coho salmon by 1991 (Brown et al. 1994). Naturally-spawned coho salmon returning to California streams were estimated to be less than one percent of their abundance at mid-century (Brown and Moyle 1991).

Weitkamp et al. (1995) reviewed the status of coho salmon in Washington, Oregon, and California. They relied upon estimates in Brown et al. (1994) for assessment of California ESUs of coho salmon. A summary of the population size data (originally from Brown et al. 1994) used in that review are in Table 8. NMFS (2001a) is an update of the Weitkamp et al. (1995) coho salmon status review that focuses on California and contains more recent information. NMFS (2001a) reviewed available data from juvenile surveys, outmigrant trapping, adult migrant trapping, spawning surveys, and redd counts. Data for the CCC Coho ESU consist largely of short time-series summer density estimates from short stream reaches. A few data sets extend into the mid- to late-1980s. The conclusions reached in these NMFS reviews are summarized below.

- Consistent patterns found in most basins within the CCC Coho ESU suggest that, while these data may not be particularly robust in detecting trends within a specific stream reach, they do appear to track large scale trends in abundance over watersheds and larger geographic areas reasonably well (Figure 16).

- For those data that extend to the mid-1980s (Caspar Creek, Little River, and Pudding Creek), the abundance in the 1990s was clearly lower than in the mid-to late 1980s.

- Overall, 126 (55%) of the 229 cohort replacement rates (CRRs)[12] calculated from the available census data were less than one, indicating a significantly ($p = 0.0045$) higher likelihood that abundance decreased rather than increased at a particular site. If a population increase is as likely as a population decrease, an equal number of observations would be expected to fall above and below 1.

- Although there is some variability among sites, the general overall trend in the 1990s is one of continued decline. The authors concluded that coho salmon in this ESU were depressed relative to historical levels and are presently in danger of extinction.

Juvenile coho salmon densities for index sites in Caspar, Pudding, Hollow Tree creeks, and Little River in the CCC Coho ESU are shown in Figure 17. The decline from the late 1980s to the late 1990s is evident. However, Caspar and Pudding creeks (Mendocino County coast) and one index site on Hollow Tree Creek (tributary to the South Fork Eel River) show a fairly substantial upward swing in 2001 (and in 2000 for Caspar Creek). Despite the recent upswing at Caspar Creek, the 1987 brood year lineage has shown a precipitous decline at both index sites since the late 1980s (Figure 18). However, counts on Caspar Creek show relatively substantial

[12] CRR = N_{t+3}/N_t; a measure of the growth rate of a population over a single generation. CRR = 1 represents replacement and no change. CRR > 1 represents a population increase. CRR < 1 represents a population decline. In a run with stable population size over all generations, CRR would oscillate around 1.

numbers of smolts of the 1987 cohort emigrating in 2001, indicating that this brood year lineage may be recovering (Figure 19). These counts also show a decline in the 1988 cohort and relatively stability for the 1989 cohort. Smolt counts on Little River show a substantial decline for the 1987 and 1988 cohorts (Figure 19).

Despite the recent increases, time series analysis for Caspar Creek and Little River coho salmon smolts and juveniles show a declining trend and predict that this trend will continue (Figures 20 and 21) . Variability in abundance in the 1990s is potentially variation around population means that are substantially lower than they were historically. Both of the time series analyses presented here exhibit a negatively inclined forecast for future expected values. The confidences that the modelled time series are a good fit to the data do show varying uncertainty. Caution must be applied in interpreting these trend lines given the limited data analysed and the limited time period of the available data. However, despite the level of uncertainty, the data sets show the same negatively inclined forecast as evidenced by both the linear trend line and the time series model. This suggests that not only are coho salmon populations in decline, they are likely to continue this decline in the future.

Current data for the SONCC Coho ESU was less available than for the CCC Coho ESU. Only one data set extended to the 1980s. NMFS (2001a) determined that arriving at conclusions about declines in this ESU were more difficult than for the CCC Coho ESU. However, analysis of available CRRs showed that in 40 (60%) of 67 paired observations, CRR was less than one. This number was significantly ($p = 0.0278$) higher than expected based on an expectation of equal numbers of CRRs above and below 1. The authors concluded that the analysis documented a general decline of the populations analyzed. With the caveat that more data may reveal further declines not seen in the available data, coho salmon in this ESU were judged not to be presently at risk of extinction, although they are likely to become endangered in the foreseeable future.

The available data on coho salmon abundance was reviewed by the Department (CDFG 1994a) in a petition to the BOF to list coho salmon as a sensitive species. Coho salmon counts at the South Fork of the Eel River at Benbow Dam were presented as evidence of decline in the region (Figure 22). Coho salmon abundance in the Eel River at Benbow Dam averaged 15,000 fish annually in the 1940s. Averages declined to about 1,800 coho salmon adults annually between 1966 and 1975, the last 10 years of counts. This represents a decline in annual average of 88%, and is an indication that the magnitude of the coho salmon decline prior to the 1970s may have been more substantial than the observed declines of more recent years in this ESU. Coho salmon counts at Sweasey Dam on the Mad River show a slight decline from the 1930s to the late 1950s, and a relatively large increase in the early 1960s (Figure 22). However, returns of adult coho salmon at Mad River Hatchery indicate a declining trend in this river in more recent years (CDFG unpubl. data).

Nehlsen et al. (1991) reviewed Pacific salmon stocks at risk. Although the review does not contain information about specific coho salmon stocks in California, it identified small coastal stream stocks in the region north of San Francisco at moderate risk of extinction, and those in small coastal streams south of San Francisco at high risk of extinction. The Klamath River was identified as being of special concern, and coho salmon stocks in small streams were identified at moderate risk of extinction. Higgins et al. (1992) reviewed watersheds north of the Russian River and identified three coho salmon stocks in the CCC Coho ESU as being of special concern, and one (Gualala River) at high risk of extinction. In the California portion of the

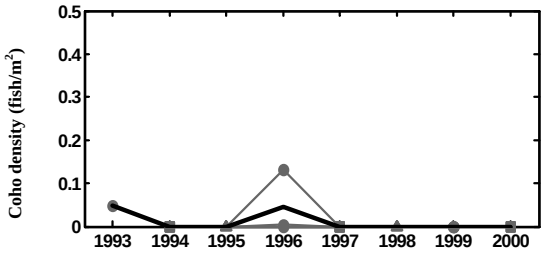
SONCC Coho ESU, ten stocks were identified as being of special concern and six at high risk of extinction.

Hatchery data are reviewed in Chapter VI, *Hatcheries*, and Chapter VII, *Hatchery Operations*. Hatchery production has declined dramatically in recent years largely due to decreases in returning spawners. Recent five-year average production for Warm Springs, Mad River, and Iron Gate hatcheries, and Noyo Egg Taking Station is only 11% to 44% of the average between 1987-91. While some of this reduction can be attributed to reduced production goals, lack of spawners has been the most important limiting natural factor. Only Trinity River Hatchery has maintained production at historical levels, and only Trinity River and Iron Gate Hatcheries currently produce relatively large numbers of coho salmon.

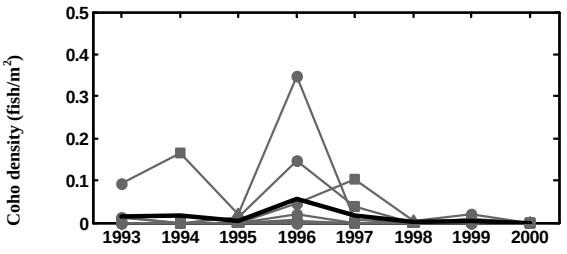
Table 8. Summary of estimated average coho salmon spawner abundance in California ESUs. Data are for the years 1987 through 1991. Reproduced from Weitkamp et al. (1995). Original estimates from Brown et al. (1994).

Region	Probably native	Native and naturalized	Hatchery	Total
Del Norte County	1,000	1,860	16,265	19,125
Humboldt County	3,480	740	891	5,111
Subtotal North of Punta Gorda[g]	4,480	2,600	17,156	24,236
Mendocino County	160	4,790	0	4,950
Sonoma County	0	635	332	967
San Francisco Bay	0	435	0	435
South of San Francisco Bay	0	140	0	140
Subtotal South of Punta Gorda	160	6,000	332	6,492
Total Spawners	4,640	8,600	17,488	30,728

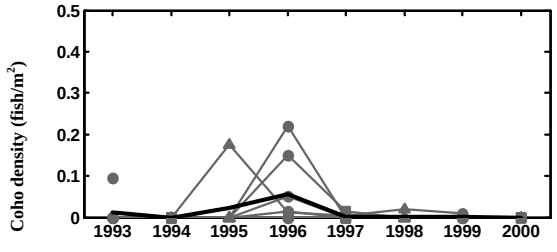
[g] A few minor streams in Humboldt County south of Punta Gorda are included in this subtotal.



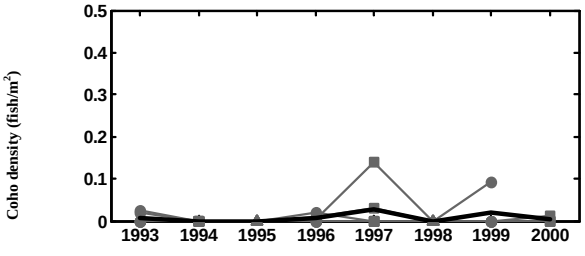
Densities for three index sites in the Usal Creek basin, Mendocino County.



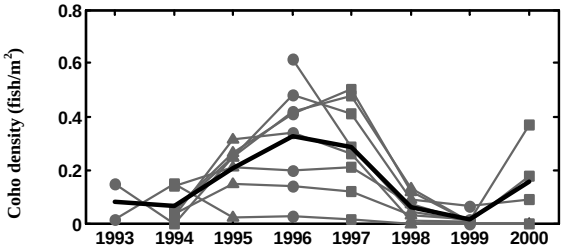
Densities for eight index sites in the South Fork Ten Mile River basin, Mendocino County.



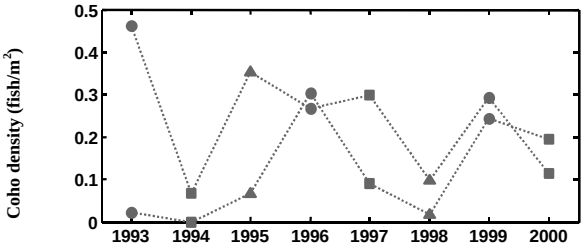
Densities for six index sites in the North Fork Ten Mile River basin, Mendocino County.



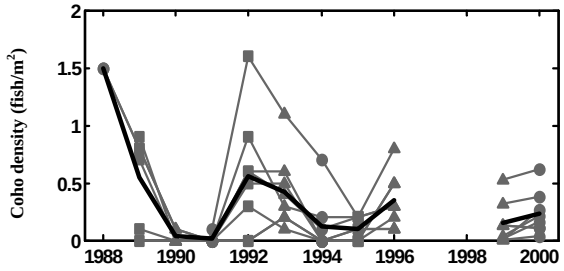
Densities for three index sites in the Middle Fork Ten Mile River basin, Mendocino County.



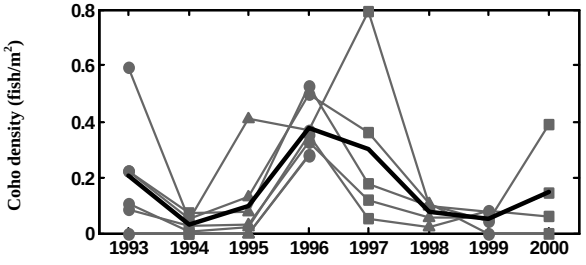
Densities for eight index sites in the Noyo River basin, Mendocino County.



Densities for two index sites in Big River, Mendocino County.



Densities for seven index sites in Albion River and its tributaries, Mendocino County.



Densities for six index sites in Big Salmon Creek and its tributaries, Mendocino County

Figure 16. Summer juvenile coho salmon densities in the Central California Coast Coho ESU (from NMFS 2001a).

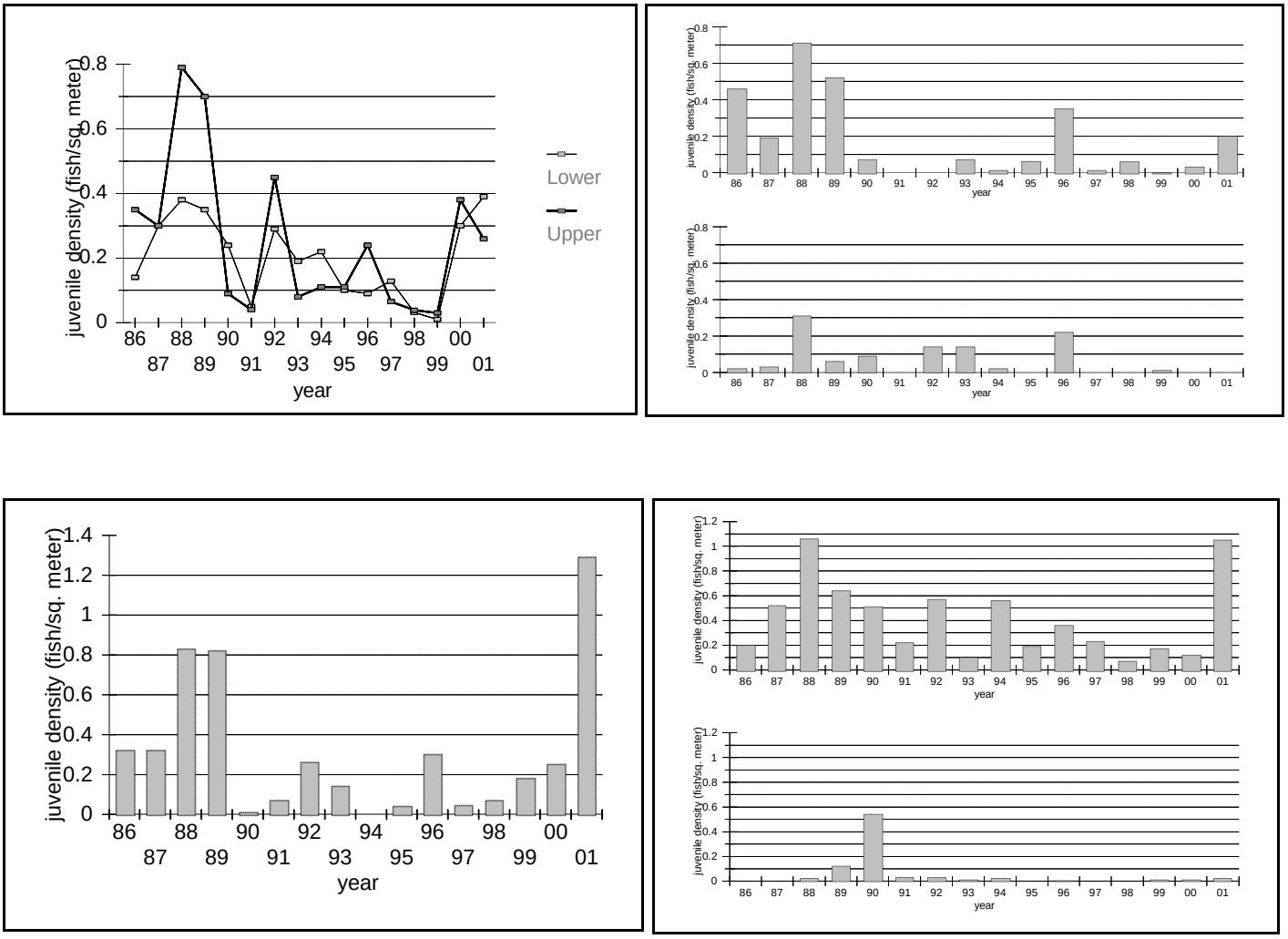


Figure 17. Juvenile coho salmon densities for: two index sites on Caspar Creek (top left); two index sites on Little River (top right); Pudding Creek (bottom left); two index sites on Hollow Tree Creek, South Fork Eel River (bottom right). No bar indicates that coho salmon were not observed during the survey in that year. (CDFG unpubl. data).

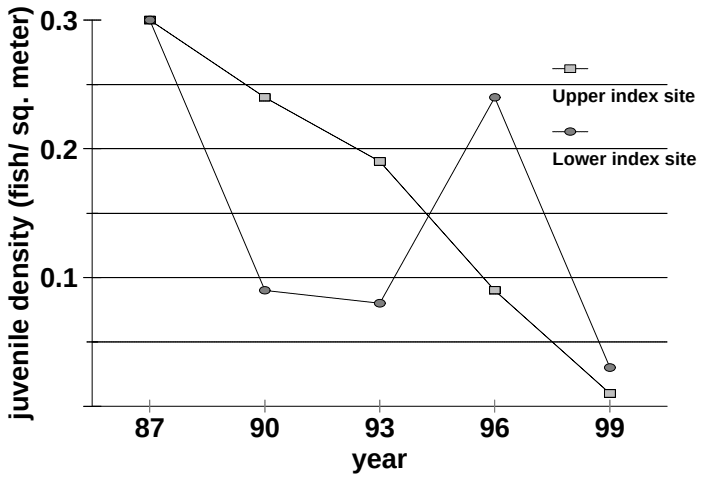


Figure 18. Juvenile coho salmon density at two index sites in Caspar Creek for the 1987 brood year lineage, 1987 to 1999.

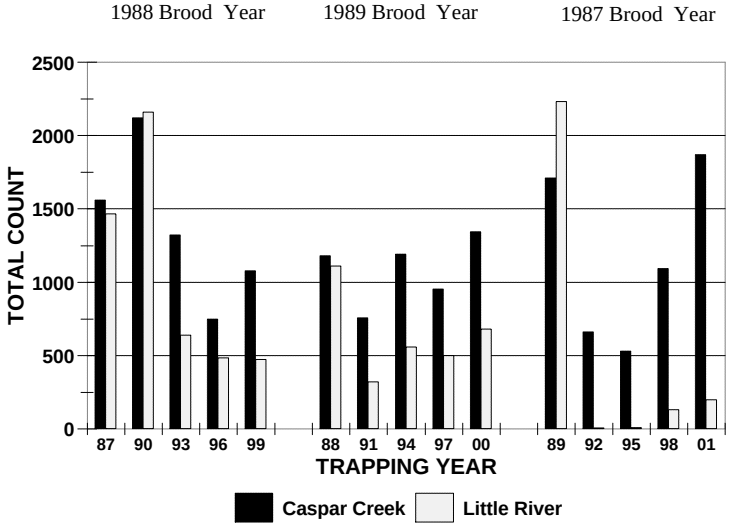


Figure 19. Coho salmon outmigration in Caspar Creek and Little River, 1987 through 2001.

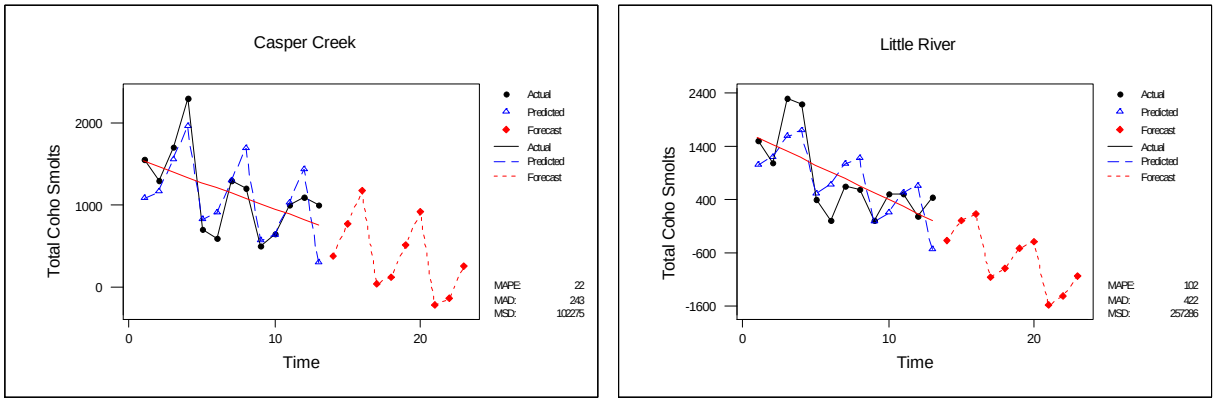


Figure 20. Time series plots and predictions for coho salmon smolt counts from Caspar Creek and Little River, Mendocino County. Decomposition time series with a seasonal trend of 4 years provided the best fit to the available data.

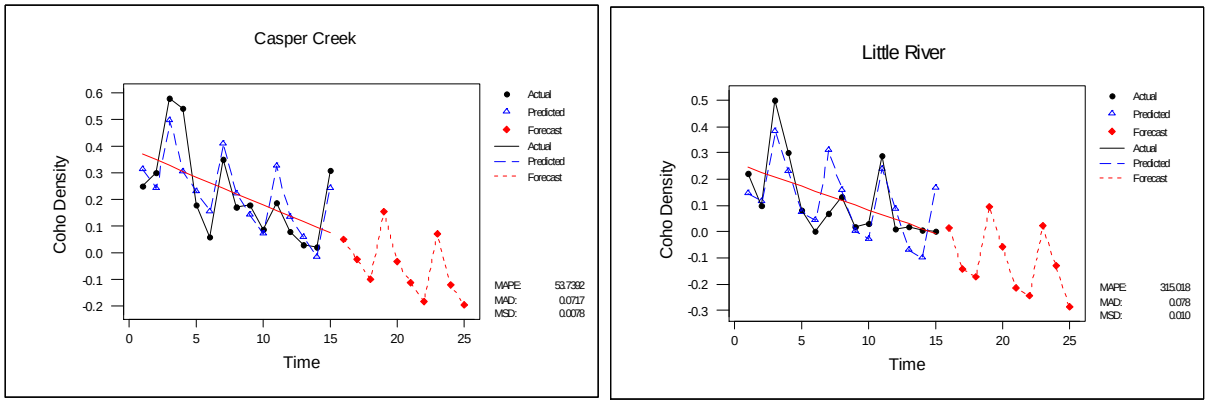
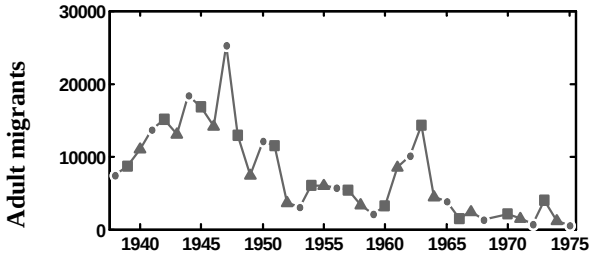
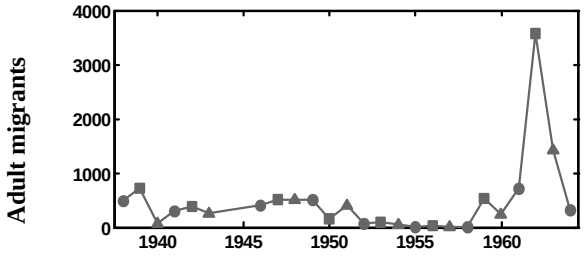


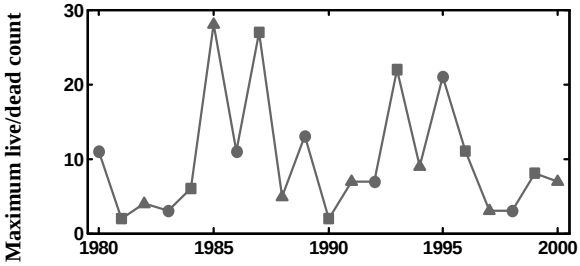
Figure 21. Time series plots with $\geq$ 10 years of data and predictions for coho salmon juvenile indices from Caspar Creek and Little River, Mendocino County. Decomposition time series with a seasonal trend of 4 years provided the best fit to the available data.



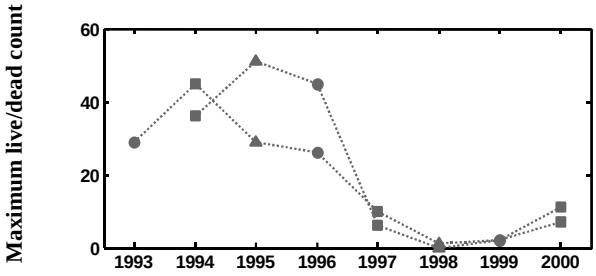
Coho counts at Benbow Dam, South Fork Eel River.



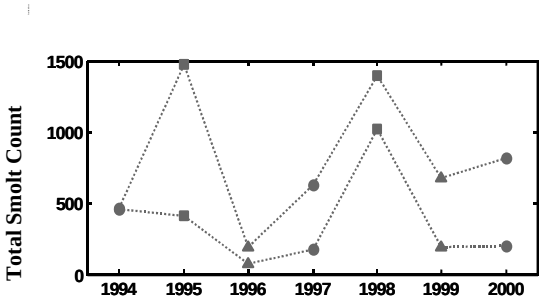
Coho counts at Sweasey Dam, Mad River.



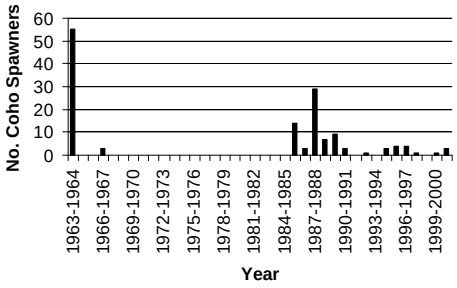
Spawner counts for West Branch of Mill Creek, Del Norte County. Symbols represent brood lineages.



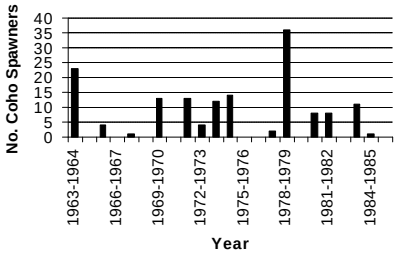
Spawner counts for West Branch of Mill Creek, Del Norte County. Symbols represent brood lineages.



Counts from downstream migrant traps in West Branch and East Branch of Mill Creek, Del Norte County.



Counts from spawner surveys on Cannon Creek, Mad River. Missing data indicates years when surveys where not done.



Counts from spawner surveys on Sprowl Creek, Eel River. Missing data indicates years when surveys where not done.

Figure 22. Abundance trend indicators in the Southern Oregon/Northern California Coast Coho ESU (from NMFS 2001a). Note the differences in the scale of the x and y axes.

Conclusions

Prior to 1994, commercial and recreational harvest provided a good measure of the decline of coho salmon statewide (Figure 15) and Pacific salmon ocean catch has been used in the literature as an estimate of abundance (Beamish and Bouillon 1993, Hare and Francis 1995, Mantua et al. 1997). Once an important part of the total salmon industry until the 1970s, coho salmon harvest dropped-off considerably in the late 1970s, and by 1992, stocks were perceived to be so low that the fishery was closed to protect them. The large catches prior to the late 1970s are correlated with, and were likely due to, increased hatchery production. However, the decline starting in the late 1970s occurred despite a fairly stable rate of hatchery production.

Southern Oregon/Northern California Coast Coho ESU

The available information on coho salmon status discussed in the previous section is primarily in the form of presence-by-brood-year analyses, field surveys conducted in 2001, recent abundance trend information for several stream systems along the central and north coasts, and ocean harvest data. Considered separately, none of these lines of investigation provide conclusive evidence that coho salmon have experienced a substantial decline throughout the SONCC Coho ESU, either because they are limited in scope or are not particularly robust in detecting trends within specific watersheds. However, most of these indicators show declining trends, and in that respect, provide a high likelihood that populations have declined significantly and are continuing to decline. Some of the indicators show an upward trend in 2000 and 2001, but the overall trend is still downward in most cases, and most indicators of abundance show values that are much reduced from historical levels. Brown and Moyle (1991) estimated that there has been a reduction in natural spawner abundance of 85% to 94% since the 1940s.

The analysis of presence-by-brood-year indicates that coho salmon occupy only about 61% of the SONCC Coho ESU streams that were identified as historical coho salmon streams by Brown and Moyle (1991) so it does appear that there has been a fairly substantial decline in distribution within this ESU (Table 5). However, our data do not support a significant decline in distribution since the late 1980s, as evidenced by the comparison of brood year presence in streams common to both the 1986-1991 and 1995-2000 periods. These analyses and the 2001 presence surveys indicate that some streams in this ESU may have lost one or more brood-year lineages.

The 2001 presence survey data may also indicate a decline in distribution in the SONCC Coho ESU. These data show a substantial reduction in the number of historical streams occupied by coho salmon, especially for the Mattole, Eel, and Smith river systems, where coho salmon appeared to be absent from 71%, 73%, and 62% of the streams surveyed, respectively. These data should be interpreted with caution, however, because they represent only one year of surveying, and the drought conditions of 2001 may have affected distribution. Nevertheless, the inability to detect coho salmon in streams that were historically documented to have contained them and are considered by biologists to contain suitable coho salmon habitat is significant, especially to the high degree that coho salmon were not found in these surveys (59% of the all streams surveyed).

Adult coho salmon counts at Benbow Dam on the South Fork Eel River show a substantial decline in this system from the late-1940s to the 1970s (Figure 22). Other trend

indicators show declining or stable trends, with the only exception being coho salmon counts at Sweasey Dam on the Mad River, which show a relatively large increase in the coho salmon population in 1962 (Figure 22). However, returns of adult coho salmon at Mad River Hatchery indicate a declining trend in this river in more recent years (CDFG unpubl. data).

Although stocks in the SONCC Coho ESU appear to be declining and distribution within the watersheds appears to be reduced, population structures within the larger systems does not show fragmentation as severe as that occurring in the CCC Coho ESU. All major stream systems within the SONCC Coho ESU still contain populations, hence it is likely that they are not as vulnerable to extirpation from adverse climatic or oceanic conditions or demographic effects of fragmented populations. Also, as discussed previously, the presence-by-brood-year analysis indicates that the decline in distribution appears to have stabilized since the mid-1980s.

Central California Coast Coho ESU

The 2001 presence surveys in the northern portion (Mendocino County) of the CCC Coho ESU show a level of occupancy of historical streams that is similar to the SONCC Coho ESU (Table 7). However, streams systems to the south of Mendocino County show a much greater proportion of streams in which coho salmon were not found. These surveys and other recent monitoring indicate that widespread extirpation or near-extinctions have already occurred within some larger stream systems (e.g. Gualala and Russian rivers) or over broad geographical areas (e.g. Sonoma County coast, San Francisco Bay tributaries, streams south of San Francisco). Only three streams in the Russian River system still contain coho salmon, and only one of these populations exists in appreciable numbers. In the Sonoma County coastal area, coho salmon appear to be extirpated or barely persisting. Coho salmon were last observed in the Gualala River system in just two tributaries in 1995, and surveys of these streams in 1999, 2000, and 2001 failed to find coho salmon. The last year of observation of coho salmon in San Francisco Bay tributaries was in 1981, despite intensive fishery surveys conducted from 1992 to 1998 (Leidy and Becker 2001). Coho salmon are now present in appreciable numbers in only three, possibly four streams south of San Francisco (NMFS 2001a).

Most abundance trend indicators for streams in the CCC Coho ESU indicate a decline since the late 1980s (Figures 16, 17, 18, and 19). However, some streams of the Mendocino County coast, such as Caspar and Pudding creeks and Little River, show a fairly substantial upward trend in 2000 and 2001 (Figure 17). In addition, there is anecdotal evidence that relatively large numbers of coho salmon adults returned to some Marin Coast streams (e.g., Lagunitas Creek) in 2001. However, time series analysis for Caspar Creek and Little River show a declining trend and predict that this trend will continue, despite the recent increases (Figures 20 and 21).

Coho salmon populations of streams in the northern portion of CCC Coho ESU seem to be relatively stable or are not declining as rapidly as those to the south. However, the widespread local extinctions that have occurred throughout the southern portion is a major and significant portion of the range of coho salmon in this ESU.